THE SEAMANS PRACTICE,

CONTAINING

A FUMDAMENTAL PROBLEM

IN

NAVIGATION,

Experimentally verified;

NAMELY,

Touching the Compaſs of the *EARTH* and *SEA*, and the Quantity of a Degree in our *Engliſh* Meaſures.

Alſo, an exact Method or Form of keeping a Reckoning at *SEA* in any kind or manner of Sailing.

With certain *TABLES* and other *Rules* Uſeful in *Navigation*; As alſo in the *Plotting* and *Surveying* of *Places*. The *Latitude* of the Principal Places in *ENGLAND*. The finding of Currents at *SEA*, and what Allowance is to be given in reſpect of them.

THE NINTH EDITION.

By RICHARD NORVVOOD, Reader of the *Mathematicks*.

LONDON,

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To the Right Honourable

ROBERT

Earl of *WARWICK*,

Baron of *LEES*, &c.

Right Honourable,

ALthough the knowledge and Practice of the Art of Navigation be of late years grown to a far greater Perfection, than it can appear to have had in any former Age; and by that means, the World, and all the parts thereof, have been further discovered, yea, sailed round about: the Traffick and entercourse of several Nations, how remote soever, facilitated: knowledge in Divine and Humane things divulged: and (which, as I conceive, is of most importance, seeming as yet to be the principal scope of the Divine Providence in discovering these Mysteries) the light of the glorious Gospel of Christ, being the mighty power of God unto salvation is extended to those silly captives of Satan in *America*, by means of those many Plantations we have amongst them: which Plantations (even from their first breathing) have received no small furtherance from your Noble favour and bounty, as I know by my own experience in that where sometimes I was, and have understood no less by others in the rest.

Yet notwithſtanding this notable growth and daily exerciſe of the Art of *Navigation*, it ſtill remains imperfect in ſome points. For whereas the practice thereof doth eſpecially conſiſt in the knowledge of Latitudes, Courſes, and diſtances; the way of finding Diſtances at Sea; namely, by the *Log* and *Line*, is rather opinionative & conjectural, than certain, being grounded upon this ſuppoſition, that the Compaſs of the World in any great Circle is 21600 *Italian* Miles (as they call them) and that ſuch an *Italian* Mile contains 1000 Paces, and every of thoſe Paces 5 *Engliſh* Feet: and according to theſe meaſures they divide their *Log-line*, and keep their account of the Ships way at Sea.

Having therefore by an Experiment which I made a year ſince, found more nearly the Compaſs of the Earth, and the quantity of a *degr.* on the ſame in our known meaſures, and applyed it to uſe in *Navigation*, in this Treatiſe followving: and further added ſome other ſuch things as I conceived to be vvanting in the Practice of that Art: I have preſumed to preſent it to your Lordſhip, as vvell becauſe by your knovvledge in *Navigation*, and the experience you have had in your Honourable enterprizes at Sea, you are vvell able to judge of it: as alſo being confident that according to your Noble diſpoſition you vvill favourably accept thereof, though othervviſe of it ſelf unvvorthy. The moſt high God ever Bleſſed and glorious, multiply unto your Honour all his Bleſſings in Chriſt Jeſus.

Your Honours in all due Obſervance,

RICHARD NORWOOD.

To the READER.

THe Circuit of the Earth and Sea (as the Circumference of every Circle) contains 360 *degr.* by which *degr.* the diſtances thereon are meaſured, ſo that the knowledge of the quantity of ſuch a *degr.* in our known meaſures, is a fundamental Principle in *Coſmography* and *Navigation*, as upon which is grounded the reckoning of the Ships way, or diſtance run. For though a Mariner being in his Voyage on the vaſt Ocean, hath ſometimes three things to certifie him where he is, and how to ſhape his Courſe to his deſired Port, namely, his Latitude, Courſe, and Diſtance; and ſometimes a fourth, namely, ſome near conjecture of his Longitude by the Variation, or otherwiſe; yet oftentimes (as in cloſe weather) he hath nothing but his Courſe and Diſtance; otherwhiles only his Latitude and Diſtance is his chief guide in falling with his intended Port. I know it is uſual to allow near 7 Fathoms or 41 $\frac{2}{3}$ Feet to a Knot, and ſo many of thoſe Knots as run out in half a Minute, ſo many Miles they account the Ships way to be in an hour. And if in half a *min.* ſhe run 41 $\frac{2}{3}$ Feet, then in 60 *min.* or an hour, ſhe runs 5000 Feet; and thus they account 5000 *Engliſh* Feet, or 1000 Paces to be a Mile, and 60 of thoſe Miles to be a *degr.* ſuch as the whole Circumference in any great Circle is 360. But how is this known to be true? If it be anſwered, that it is known to be ſo by Experience; then I would know further by what Experiment this was found to be ſo? Where, & by whom made? I preſs this ſo much the rather, becauſe I am perſwaded we have at this day as many excellent *Navigators* in this Kingdom, and as great Voyages performed, as from any other place in the World; and I ſhould be glad to hear of the experimental reſolution of this *Problem* by ſome of them, though it were but in running 8 or 10 *degr.* near the Meridian: for ſo I doubt not but that which I have here written thereof, would receive further confirmation, and better entertainment, than happily it will now, being ſo much different from the common opinion, and the Arts of *Navigation* and *Coſmography*, would be much more perfected in ſhort time. For one Errour (as a frutful Mother) is oftentimes the cauſe of more, and ſo the removing of one is the occaſion of removing others, eſpecially when they do mutually ſupport one another: As we ſhall here ſhew how the Errour in the projection and uſe of the common *Sea-Chart*, is ſupported by this Errour of accounting only 300000 of our feet to a *degr.* and this in like ſort upheld by that, ſo that they will ſtand or fall together. And ſurely that had fallen long ſince, being ſo manifeſtly convinced, if it had not been upheld by this. For the confuting

confuting of that, (I mean the common *Sea-Chart*) it was ſufficient to know that the Earth and Sea make one Spherical body, but in diſproving and rectifying this, it is neceſſary to know moreover what is the quantity of that Spherical body: and to that end it was neceſſary to make a ſenſible application of our known Meaſures, to a determined part of the whole, that ſo the quantity of that determined part being known, and the proportion thereof to the whole, the quantity of the whole might alſo be diſcovered. And this I have endeavoured in the Experiment following, which if I have not handled ſo exactly in all points as ſome would deſire: That requiring more time and charge (than I could well beſtow) yet I doubt not but it will be found that I have come very near the Truth. Some happily will cenſure me for being my ſelf at the expence to make ſuch an experiment. But I was as frugal in it as I could, adding pains and induſtry to ſave expence; I came up in 10 or 11 days, and had other neceſſary occaſions to lead me from the one place to the other, and did this as a thing falling opportunely in my way. But indeed (as in all other parts of Learning) ſo in the Mathematicks, eſpecially in their application, or middle Mathematicks (as ſome call them) it is neceſſary with Speculation to join actual and experimental practices; the former being empty and uncertain without theſe. It is true, that the Mathematicks afford large Fields of delightful ſpeculations, wherein a Man might walk far with much pleaſure: But if from ſo many fair Flowers he bring home no honey, or from ſuch large Fields no ſheaves: I mean, if he bring not thoſe Speculations to ſome uſeful practices, neither himſelf nor others are like to receive much fruit by them. But this indeed cannot be effected without more labour and difficulty, yet ſometimes it requires Mechanical and bodily exerciſes, which ſome eſteem too mean and unworthy to ſtoop unto. But for mine own part, I acknowledge to have had my living and maintenance by the Mathematicks, and not by Speculation only, but rather by my practice therein; and therefore alſo I deſire (what in me lies) to make them fruitful to my ſelf and others: And to that end have ſpent in ſome Principal parts of the Mathematicks, near as much time and means in experimental practices and Concluſions, as in the Speculation: Moreover, conſidering that this particular Experiment was propoſed above 30 years ſince by our Countreyman Mr. *Edward Wright*, to invite ſome to the tryal of it, as a thing which he would have done himſelf, if he had found ſuch furtherance and opportunity as he deſired, which it ſeems he did not, nor any other ſince that time. Rather than ſo noble and ſo neceſſary a *Problem* ſhould longer reſt unreſolved, I took the opportunity offered, hoping it may be an occaſion to whet on ſome others to do the like. This with ſome other things which I conceived to be wanting in the practice of *Navigation*, I have handled in this enſuing Treatiſe, which I commend to your friendly acceptance, *Farewel.*

Ju'y *the firſt*, 1636. THE

THE SEA-MANS Practice.

CHAP. I.

The common Opinion touching the Compaſs of the Earth, and quantity of a Degree of the ſame.

IT is a common received Opinion in *England* (and the like is in other places) that allowing 5 of our *Engliſh* Feet to a Geometrical Pace, 1000 of thoſe Paces make an *Italian* Mile, and 60 of thoſe Miles in any great Circle upon the Spherical Surface of the Earth or Sea make a Degree; and thus it is ſuppoſed, that a Degree contains 60 Miles, or 60000 Paces, or 300000 of our *Engliſh* Feet, and by ſuch Miles do Mariners in their Voyages by Sea keep their Reckonings: And becauſe the whole Circumference of a Circle is 360 Degrees, therefore the compaſs of the Earth, according to this Opinion, ſhould be 21600 ſuch *Italian* Miles, or 21600000 Paces, or 108000000 of our *Engliſh* Feet. Whence this Opinion came, or upon what experiment it ſhould be grounded, I cannot certainly ſay; It may ſeem to be taken, or rather miſtaken from *Ptolomy*; who ſaith, there

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are 500 *Stadiums* in a Degree, the ſame was before affirmed by *Martinus Tyrius*, of whom *Ptolomy* ſpeaking in the 11 Chap. of his firſt Book of *Geography*, hath theſe words, *Sed in hoc quoque rectè ſentit partem unum qualium eſt circulus maximus tricentorum ſexaginta, quinginta in terra conſtituere Stadia, id enim confeſſis dimenſionibus conſonum exiſtit.* Now a *Stadium* not only amongſt the *Greeks*, but as appears by *Herodotus*, amongſt all other Nations of *Aſia* and in *Egypt*, did conſiſt of 600 Feet, or 100 *Orgyas*, an *Orgya* containing 6 Feet or 4 Cubits, as our Fathom doth: the ſame alſo is teſtifyed by *Suidas*, and others: ſo that a *deg.* containing 500 *Stadiums*, and every *Stadium* 600 Feet, it follows that a *deg.* muſt contain 300000 Feet, exactly agreeing in number with the common received opinion in *England*, which therefore may ſeem to be hence derived, and would alſo receive much confirmation hereby (he being an Author of ſuch approved credit) if it could be approved that our *Engliſh* Feet were exactly equal to the *Egyptian* or *Alexandrian* Foot, where *Ptolomy* wrote. Otherwiſe that being true, that ſo many of their Feet make a *deg.* it will follow, that if ours be greater, there be fewer of them contained in a *deg.* if leſſer, (as undoubtedly they are) there muſt be more of them contained in a *degr.*

Philander in his Commentary upon the third Chap. of the third Book of *Vitruvius*, hath expreſſed the quantity of the ancient *Roman* foot, where (by a competent allowance for the ſhrinking of the Paper being Printed wet) it may probably be gathered that it was ſomething longer than our *Engliſh* Foot. But the *Alexandrian* and *Egyptian* Foot was much greater, for according to *Heromechanicus*, 5 *Alexandrian* Feet were equal to 6 *Roman* Feet: ſeeing then the ancient *Roman* Foot was ſomething greater than ours, the *Alexandrian* foot muſt needs be much greater than ours. So that whereas *Ptolomy* ſaith there are 500 *Stadiums* in a Degree, and as we have ſhewed a *Stadium* did conſiſt of 600 feet, theſe being *Egyptian* or *Alexandrian* feet, as it is moſt probable, being the place where *Ptolomy* lived; there muſt be a far greater number of our Feet in a *Stadium*, and ſo in a Degree; whence it is evident, that there is no ſufficient footing for this common opinion in the aſſertion of *Ptolomy*. Neither

Neither doth the Practice and Experience of Mariners in their Voyages at Sea prove it; for there is no reckoning or experiment at Sea set down by any (that I have seen) to confirm it. And though it be true, that in Sailing between two places that lie near to one and the same Parallel, they ground their reckoning chiefly upon this supposition, that 300000 of our *English* Feet make a Degree; yet can they seldom or never by those reckonings discern the Errour, the rather for that they have been, and for the most part are still kept upon the Plain or Common *Sea-Chart*, which makes a Degree in any Parallel equal to a Degree in the Equinoctial, and so makes a Degree in any Parallel to contain 300000 Feet: And it is true, that in some Parallel a Degree doth contain only 300000 of our *English* Feet; namely, about that Parallel which is in Latitude 35 Degrees (as we shall further shew hereafter) near unto which have the principal of our Eastern and Western Voyages been made. And thus, though this Opinion of 300000 Feet in a Degree, and the Projection of the *Common-Chart* be both erronious; yet because the errour of the one doth something salve the other, they could not be so easily discerned by Experience only.

This Opinion of 300000 *English* Feet to a Degree, may seem also to be something confirmed by an Observation made by our Countrey-man Master *Edward Wright*, upon Mount *Edgcomb* near *Plimouth*, of the Semidiametre of the Earth, which he hath set down in his Book, *Of the Correction of Errours in Navigation*, Chapter 15. where he finds the Semidiameter to be 18312621 of our *English* Feet, whence it may be gathered, that in a Degree of a great Circle of the Earth, there should not be full out 320000 of our Feet; but the way by him then used, though it was very fit for the end whereunto he there applies it; namely, to find the dipping or depression of the apparent Horizon beneath the true, according to the heighth of the Eye above the water; yet will it easily be granted to be no exact way for finding the Semidiameter, and consequently the Circumference of the Earth, or the Quantitie of a Degree

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on the ſame; and ſo he ſays there, that he uſed that way, becauſe he wanted opportunity to put in practice a more exact way. Wherefore for the further ſatisfaction of my ſelf and others in this Point, and chiefly for the neceſſary uſe it hath in the Practice of *Navigation*, I have made the experiment following, that ſo the quantity of a Degree, and of the whole Compaſs of the Earth, might at leaſt-wiſe be nearly known in our *Engliſh* Meaſures.

CHAP. II.

An Experiment made for finding the quantity of a Deg. *and ſo the Circumference of the Earth and Sea in our known Meaſures.*

HAving occaſion to be in the City of *York*, about the beginning of *June*, *Anno* 1635. I made there ſeveral Obſervations of the Meridian Altitude of the Sun, the laſt of which was made the 11 day of *June*, the Skie was every of thoſe days ſomething overcaſt at Noon, yet not ſo much but that an Obſervation might be made to near ſcantling: And becauſe the laſt of thoſe Obſervations is moſt fit for the preſent occaſion, and that Day was as clear as any of the other, we will here eſpecially make uſe of that, being as followeth.

Upon the 11 of *June* 1635. I made an Obſervation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an Arch of a *Sextant* of more than 5 Foot Semidiameter, and found the apparent Altitude of the Sun that Day at Noon to be 59 *deg.* 33 *min.*

I had alſo formerly upon the 11 Day of *June*, *Anno* 1633. obſerved in the City of *London*, near the Tower, the apparent Meridian Altitude of the Sun, and found the ſame to be 62 *deg.* 1 *min.*

And

And seeing the Suns Declination upon the 11 Day of *June* 1635, and upon the 6th Day of *June* 1633, was one and the same without any sensible Difference; and because these Altitudes differ but little, we shall not need to make any alteration or allowance, in respect of Declination, Refraction, or Parallax: Wherefore Substracting the lesser apparent Altitude; namely, 59 *degr.* 33 *min.* from the greater 62 *degr.* 1 *min.* there remains 2 *degr.* 28 *min.* which is the Difference of Latitude of these two Cities; namely, of *London* and *York*.

Also by the aforesaid Observation made in *York*, it appears, that the Latitude of that City, is 53 Degrees, 58 Minutes almost.

But to our purpose; Coming at that time from thence to *London*, I further found by Measure, that the Parallel of *York*, is from the Parallel of *London*, 9149 Chains; every Chain being 6 Poles, and every Pole $16\frac{1}{2}$ of our *English* Feet; that is, every Chain 99 Feet. (After what manner I found this to be so, we shall further express hereafter:) But thus, as I say, I found that *York* is more Northerly than *London*, by 9149 Chains: And before we have noted that these two places differ in Latitude 2 Degrees 28 Minutes: therefore it follows, that 2 Degrees 28 Minutes of the Meridian of the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of these Chains are contained in 1 Degree, we may find that by the Rule of Proportion, first reducing the Degrees into Minutes, and then say,

If the difference of Latitude	148 *co. ar.*	7.82974
give such a number of Chains.	9149	3.96137
Then 1 Degree, that is	60	1.77815
gives of such Chains	3709	3.56926

and somewhat more, namely, 5 Feet, which reduced into Feet, make 367196; that is, 367200 Feet in a Degree, lacking 4 Feet, which here we regard not.

Thus then, according to this Experiment, it is evident, that one Degree of a great Circle meaſured on the Earth is near 367200 Feet, which in our Poles of 16½ Feet, is 22254 Poles, and about one half, and theſe reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles: and laſtly, theſe reduced into our *Engliſh* Miles, of 8 Furlongs to a Mile, makes 69 Miles, and 4 Furlongs 14 Poles, that is 69½ Miles and 14 Poles in a Degree.

And hence, according to the moſt approved *Hypotheſis* of the Sphericity of this Terreſtrial Globe, we may find the Compaſs of it as followeth. But firſt, you may Note that we ſpeak not here of the Compaſs of the Earth in any Parallel, or leſſer Circle deſcribed upon any ſide thereof, that being various according to the different diſtance of thoſe Circles from their Poles) but of the Compaſs taken in the middle or greateſt thickneſs of the Globe; namely, in any great Circle, ſuch as divide the whole Globe into two equal parts, of which kind are the Equinoctial and all Meridians, *&c.* this being properly the *Perimeter* or *Compaſs* of a *Spherical Body.*

Now ſeeing a Degree is the 360 part of the Circumference of a Circle (for any Circumference being divided actually or by ſuppoſition into 360 equal parts, thoſe parts are called Degrees) if we can find how many Feet, Paces, Miles, or other known meaſures are contained in one of thoſe Degrees, then ſhall we eaſily conclude how many of the ſame known meaſures are contained in the whole Circumference: But by the former Experiment we find, that in one *deg.* of a great Circle on the *Spherical Superficies* of the Earth there is contained 367200 Feet; therefore it is evident that 360 times 367200 Feet is the Compaſs of the whole; wherefore multiplying 367200 by 360, the Product is 132192000 Feet, which reduced into Poles is 8011636, and theſe reduced into Furlongs, are 200290 Furlongs 36 Poles: and laſtly, theſe reduced into Miles, are 25036 *Engliſh* Miles, and ſomewhat more, for the Circuit of the Earth and Sea.

If

If further we desire the Diameter and Semidiameter of the Earth: Forasmuch as it is proved by *Archimedes*, that the proportion of the Circumference of a Circle is to the Diameter thereof, almost as 22 to 7: Therefore by the Rule of Proportion, as 22 to 7: so is the Circumference of the Earth, to the Diameter thereof: So that multiplying the Circumference of the Earth; namely, 132192000 Feet by 7, and Dividing the Product, namely, 925344000 by 22 the Quotient, namely, 4206191 is the Diameter of the Earth in Feet, the half whereof, namely, 21030545 Feet is the Semidiameter of the same, being 21 millions of Feet, and somewhat more: these reduced into *English* Miles, as before we did the Circumference, shew the Diameter of the Earth to be 7966 miles and somewhat more, and the Semidiameter 3983. And thus we have the Circumference, Diameter, and Semidiameter of the Earth, as also the Quantity of a Degree of the same Circumference in known measures of Feet, Furlongs, and Miles, *&c.* There are only two things here, which may seem doubtful; namely, the Experiment it self, and the *Hypothesis* of the Sphericity of this *Terrestrial Globe* consisting of the Earth and Sea; for these being admitted, the measures thence reduced as before, will necessarily follow.

Now touching the Experiment; I confess, that to have made it so exactly as were requisite, and in all Points so as I shall shew in the Chapter following, would have required much more time and expence than mine ability would reach unto; Yet having made Observation at *York*, as aforesaid, I measured (for the most part) the way from thence to *London*; and where I measured not I paced; (wherein through Custom I usually come very near the truth) observing all the way as I came, with a Circumferentor all the principal Angles of Position or Windings of the way (with convenient allowance for other lesser Windings, Ascents and Descents,) and these I laid not down by a Protractor after the usual manner, but framed a Table much more exact and fit for this purpose, as we shall hereafter shew; so that I may affirm the Experiment to be near the truth.

Touching

Touching the *Hypotheſis*, that the Earth and Sea make one Spherical or round Body, it is generally agreed upon by all the principal Philoſophers, Aſtronomers, Geographers, and Navigators, Ancient and Modern, ſome reaſons demonſtrative for the confirmation thereof, may be theſe.

Firſt, the Eclipſes, eſpecially of the Moon, which are cauſed by the ſhadow of the Body of the Earth, being interpoſed between the Sun and the Moon; and foraſmuch as this ſhadow doth fall upon the Moon, always and upon every ſide Circular, and ſo appears to us, it is manifeſt by the Opticks, that the Earth from whence it proceeds is a Spherical Body.

Secondly, Likewiſe the Eclipſes of the Sun, which are cauſed by the interpoſition of the Moon between the Sun; and thoſe places where it appears Eclipſed; I ſay, it could not be determined when, and in what place ſuch an Eclipſe ſhould appear, and where not, if the form of the Earth were not known; but ſeeing the places where ſuch Eclipſes happen, and where not, may be, and are uſually determined, and that upon this Ground; that the Surface of the Earth is Spherical, it is thence alſo ratifyed to be a truth.

Thirdly, the Sun, Moon, and Stars do riſe and ſet, and are upon the Meridian ſooner to thoſe that are reſident in the Eaſtern parts, than to others more Weſterly, and that in a proportion anſwerable to the roundneſs of the Earth, as the Planets and Stars are upon our Meridian at *London* ſooner by almoſt 4 hours, than they are to thoſe that Inhabit *Summer Iſlands*, and the confines of *Virginia* and *New England*: And ſo in *Eaſt India*, and other Eaſtern Regions, the Sun and Stars are ſooner upon their Meridian than upon ours; which is manifeſt to be ſo, as by other reaſons, ſo eſpecially by the Eclipſes of the Moon: for an Eclipſe of the Moon hath not in it ſelf any diverſity of time, being at one and the ſame inſtant without reſpect of places, yet becauſe in the Eaſtern parts the Day is begun, and it may be far ſpent, before it begin in places far Weſterly, therefore ſuch an Eclipſe may appear to the Eaſtern Inhabitants towards the end of their Night, which to the Weſtern appears in the beginning

ginning or middle of the same Night with them, and so the difference will be more or less, according to the different distance of those places in Longitude.

Fourthly, Furthermore we see, that going or Sailing to the Northwards, We have the Artick Pole and Southern Stars more elevated, and the Antartick Pole and Southern Stars more depressed, the Elevation Northerly increasing equally, with the depression Southerly, and either of them proportional to the Distances which we go: The like happeneth in going to the Southwards. Besides the Oblique Ascensions, Descensions, Occultations, Emersions, and Amplitudes of Rising and Setting of the Sun and Stars, in every several Latitude, agreeable to the *Hypothesis* of the Earth's Sphericity. All which could not be so, if the Earth were of any other than of a Spherical form.

Fifthly, So if we stand upon the Sea-shore, and see a Ship far off under Sail, making towards the Land, at first we see only the Top-Sails or highest parts, and withal do manifestly behold the Convex Superficies of the Sea, as it were raised and interposing her self between our sight and the Hull, or lower parts of the Ship, till she approacheth nearer, and this uniformly, every ways alike, and proportionably to the several Distances; which doth evidently demonstrate the Spherical roundness thereof.

Sixthly, And lastly, (to add no more) the Navigations of these later times make it apparent, those especially that have been made round about the World, as those two Voyages by our famous Country-men Sir *Francis Drake*, and Mr. *Thomas Candish*, both which severally Sailing from our Coasts to the *West-Indies*, and passing the Streights of *Magellane*, continued their Course Westerly, till they came into those parts, which are from us to the Eastwards, namely, to the *East-indies*, and so Sailed still Westerly till they came to *Cape bon Esperance*, and thence returned into *England*: Having Sailed about the whole Terrestrial Globe, they found nothing by their observations or Reckonings dissonant from the uniform *Sphericity* thereof in all its parts. That they came short in the number of Days, one, or reckoned the time of their absence less by one Day and a Night than they

which

which remained at home; this further confirms the thing in hand.

Yet whilſt we ſpeak here of the Roundneſs of the Earth and Sea, we intend it not ſo ſtrictly as if it were a thing turned round without any inequality in its Superficies: But as a Bowl or Ball though it have ſome duſt or ſmall grains of Sand cleaving thereto, may ſtill be ſaid to be round: So, though the Land, Hills, and Mountains be ſomewhat raiſed above the Spherical Superficies of the Sea; and if there ſhould be alſo ſome Valleys or Bottoms more depreſſed; yet ſeeing the greateſt of theſe inequalities have ſcarce any ſenſible proportion of the whole, we may well affirm the whole to be round.

The Relations made of the Prodigious height of ſome Mountains, as to be 60 or 70 Miles high, if it be underſtood of their perpendicular or direct height, are fabulous; the Mount *Atlas* Recorded by ſome of the Ancients, to reach up almoſt to the Moon, and to be as it were a Pillar for the Heavens to wreſt upon, being meaſured Geometrically by *Eratoſthenes*, the perpendicular or upright height from the top thereof to the Valleys beneath, was found not to exceed 10 *Stadiums*, which of our *Engliſh* meaſures is little more than a Mile and a quarter, a *Stadium* not much differing from our Furlong; and the like might be ſhewed of others.

But if we admit the higheſt Mountain to riſe perpendicularly above the Spherical Superficies of the Sea 2 Miles; yet ſeeing the Diameter or whole thickneſs of the Earth, is, as we have before ſhewed, 7966 Miles, this exorbitancy or difference of 2 Miles is of ſmall moment; yea, if there were any Mountain 8 Miles in height upright, yet this compared with the whole thickneſs of the Earth, is little more than one thouſand part thereof; therefore we may conclude, that this *Terreſtrial Globe*, conſiſting of the Earth and Sea, is *Spherical*. We come in the next place to ſhew by what way of Meaſuring we found the Parallel of *York*, to be diſtant from the Parallel of *London*, 9149 Chains And ſo how the Diſtance of the Parallels of two Places may be exactly meaſured.

CHAP. III.

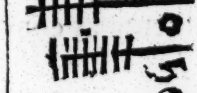
CHAP. III.

A most exact way for finding the quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the same.

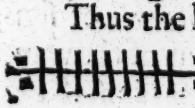
I Do the more fully set down the way of making this Experiment, that so I may give occasion to any who are so Nobly minded for a Publick good, as to be at that Charge to make a further and more exact tryal thereof. Now then, the best and perfectest way is, to observe so exactly as may be the Summer *Solstitial Altitudes* of the Sun at two places, so far distant asunder, and lying so near North and South each from other, with so direct and fair a way betwixt them, as conveniently may be chosen: Suppose for Example, *Christ-Church* and *Berwick*, or some other place in the furthest parts of *Scotland*, for the further these two places are each from other, the more perfectly may this business be performed. Then measure as truly as is possible, and set down in a Book, all the way between those two places, with all the Windings, Ascents and Descents that are therein, whereby with the help of the ensuing Table, you may easily and exactly find how much the one place is more Southerly than the other. For this purpose the *Plain Table* is not the fittest Instrument, but rather a *Theodolite* or *Peractor*, or some other of that kind, observing diligently the Variation of the Needle. The Chain may be 6 Poles long, or rather a 100 Feet, and the Table fitted accordingly (but the Table following is for Poles) if it should be much longer, it would be too heavy.

The High-ways are commonly crooked, yet because of sundry obstacles and impediments which are incident out of the way, and because a Man cannot certainly at first direct himself the nearest and best way to the place intended, it would be expedient to measure the Distance as aforesaid; First, in the High-ways

leading from the one to the other, and then in the neareſt and beſt way that could be choſen between them; and ſo if any notable Errour happen in the one, it may be diſcovered and amended in the other. The form which I obſerved in ſetting down the meaſures and Angles, was according to this Example.

Deg.		*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
S E	31					
S E	20					
S E	13					
S E	13					
S W	02					
S E	05					

It is to be underſtood, that the Table here following was before Calculated to ſerve inſtead of a *Protractor*, for a *Circumferentor*, or other Graduated Inſtrument, and for a Chain of 3 Poles, which for the moſt part I uſe; yet it may very well be applyed to a Chain of 6 Poles, (as in this buſineſs it was) reckoning every Chain to be two, *&c.* And thus for every ten Chains of ſix Poles to a Chain, I make two Strokes, ſignifying two Changes or 20 Chains; and if there be any odd Chains, for thoſe I ſet a Figure in another Line next below; and if moreover any odd Poles, whether one or two, for thoſe I ſet another Figure in a third Line below.

Thus the laſt entrance before-going, being *S E* 05 *degr.*  ſignifies that the Line upon which I went, was

from the South part of the Meridian of 5 *degr.* the 9 Strokes ſignifie 9 Changes, or 90 Chains; the Figure 5 ſignifyeth five Chains, and the Figure 2 two Poles. So that it is to be read thus, South-Eaſterly 5 Degrees, 9 Changes, 5 Chains, and 2 Poles; and the like is to be underſtood of the reſt. But for the moſt part having liberty of Ground, I end the meaſure of every Line, either with a whole number of Changes, or at leaſt of Chains.

And thus proceeding all Day, towards the Evening, or when elſe I have a time convenient, I reduce all theſe Diſtances, upon what Lines or Angles ſoever they be, to Diſtances of North or South, Eaſt or Weſt, as here appears.

Deg.	*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
			2571	1545	
S E 31			2819	1026	
S E 20			1692	616	
			0169	062	
S E 13			2823	675	
			1754	404	
S E 13			1699		052
			2690	235	
S W 02			0149	013	
S E 05			0020	002	
Chains	571		16286	4578	052
	2		0	52	
Poles.	1715		16286	4526	

We will explain the laſt, and ſo the reſt may eaſily be underſtood: *S E 5 deg* ||||||| | -5.2. Here becauſe I have *S. E.* the numbers taken out of the Table muſt be put into the Columns entituled *South* & *Eaſt.* Then in the Table under 5 *deg.* I look

for 9 Changes, and find againſt it 2690, and in the adjacent Columnn under the Complement thereof 235; and becauſe *SE* 5 *degr.* is leſs than 45 *degr.* that is, nearer to the South than to the Eaſt. I put in the Column entituled South 2690, and in that entituled Eaſt 235; then again in the ſame Tabular Column under 5 *degr.* I find againſt 5 Chains, (cutting off a Figure; becauſe 5 Chains is but the tenth part of 5 Changes) 149 to be put in the South Column, and 13 for the Eaſt Column.

Laſtly, againſt 2 Poles I find for the South Column 20, and for the Eaſt 2; and the like is to be underſtood of all the reſt.

Now ſuppoſing this laſt to be a Place, whoſe Diſtance and Scituation from the firſt is required; I ſum up the Columns ſeverally, and of the North and South Columns Subſtract the leſſer from the greater, and ſo of the Eaſt and Weſt Columns; and ſo it will appear how much North or South, and how much Eaſt or Weſt the laſt place is from the firſt.

As in this Example, we find the laſt place to be to the Southwards of the firſt 1628 Poles, for the laſt Figure may be cut off, being uſed in the Table, only for the more exactneſs, or may be made a Fraction, and ſo it is $1628\frac{6}{10}$ Poles; Likewiſe, the laſt place is to the Eaſtwards of the firſt $452\frac{6}{10}$ Poles; and thus I proceed all the way.

Now touching the Angles of Aſcent and Deſcent of Hills and Valleys, to have obſerved them exactly, would have required more Time and Charge than I could my ſelf beſtow; yet I made allowance for ſuch of them as were of moſt moment; He that would obſerve them all, may either make 2 or 3 Columns more, or keep an account of them apart by themſelves. But if he intend no further uſe of them, but to find the neareſt Diſtance, he need not ſet them down, but make allowance for them on the Ground, keeping his Diſtance intire without Fractions.

As, admit I obſerve the Aſcent from a Valley to the brow of a Hill to be 14 *degr.* above the Level or Horizontal Line, and that meaſuring, I find the Diſtance to be 30 Poles; I turn to the Table, and under 14 *degr.* and againſt 10 Chains, I find 2911, and 726, ſhewing that the Level or Horizontal Diſtance from

my

my Station, to that Brow. is only 29 $\frac{11}{100}$ Poles, and that the height of that Brow above the Level Line, is 7 $\frac{84}{100}$ Poles: But finding thus that the *Hypothenuſal* being 30, the Baſe or Level Line it but 29 $\frac{11}{100}$, that is leſs by $\frac{89}{100}$, becauſe I would avoid this Fraction, I add to the end of the foreſaid meaſure of 30 Poles upon a Level Line, $\frac{89}{100}$ of a Pole, and then I may account my ſelf diſtant from the place in the Valley where I made Obſervation, 30 Poles in a Level Horizontal Line, and ſo ſet down the Diſtance without a Fraction: the like is to be underſtood of all other Aſcents and Deſcents.

Here followeth the Table.

	1. *d.*	89 *d.*	2 *d.*	88 *d.*	3 *d.*	87 *d.*	4 *d.*	86 *d*	5 *d.*	85 *d*
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	598	63	896	76
4	1200	20	1200	42	1198	62	1198	84	1197	105
5	1500	26	1500	53	1497	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2094	79	2097	110	2095	147	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	2993	210	2989	262
1	10	00	10	0	10	0	10	1	10	1
2	20	00	20	1	20	1	20	1	20	2

	6. d.	84 d.	7 d.	83 d.	8 d.	82 d.	9 d.	81 d.	10 d.	80 d.
1	298	31	298	37	297	42	296	47	295	52
2	597	62	596	74	594	84	592	94	590	104
3	895	94	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1489	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2089	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	283	2680	329	2674	376	2667	422	2659	469
10	2984	314	2978	366	2971	418	2963	469	2954	521
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11 d.	79 d.	12 d.	78 d.	13 d.	77 d.	14 d.	76 d.	15 d.	75 d.
1	295	57	293	67	291	67	290	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2631	608	2620	653	2610	699
10	2945	572	2934	624	2929	675	2911	726	2898	776
1	10	2	10	2	10	2	10	2	10	3
2	19	4	19	4	19	4	19	4	19	5

	16 d.	74 d.	17 d.	73 d.	18 d.	72 d.	19 d.	71 d.	20 d.	70 d.
1	288	83	287	88	285	93	284	98	282	103
2	576	166	574	177	570	186	568	196	564	206
3	865	250	861	264	855	279	851	294	846	308
4	1153	332	1148	352	1140	371	1135	391	1128	411
5	1442	413	1434	438	1426	463	1418	488	1410	513
6	1730	496	1721	526	1711	556	1702	586	1691	616
7	2019	580	2008	615	1997	649	1986	684	1973	719
8	2307	663	2296	703	2282	743	2270	782	2255	822
9	2596	746	2583	791	2567	836	2552	880	2537	924
10	2884	827	2869	877	2853	927	2836	977	2819	1026
1	10	3	10	3	10	3	10	3	10	3
2	20	5	19	6	19	6	19	6	19	6

	21 d.	69 d.	22 d.	68 d.	23 d.	67 d.	24 d.	66 d.	25 d.	65 d.
1	280	107	278	112	276	117	274	122	272	127
2	560	215	556	224	552	234	548	244	544	254
3	840	322	834	337	828	351	822	366	816	381
4	1120	429	1112	449	1104	468	1096	488	1088	508
5	1400	537	1391	562	1380	586	1370	610	1360	634
6	1680	645	1669	674	1656	703	1644	732	1632	761
7	1960	752	1947	786	1932	820	1918	854	1904	888
8	2240	860	2225	899	2209	937	2192	976	2175	1015
9	2521	968	2504	1011	2485	1054	2466	1098	2447	1142
10	2801	1075	2782	1124	2761	1172	2740	1220	2719	1268
1	9	4	9	4	9	4	9	4	9	4
2	18	7	18	8	18	8	18	8	18	8

	26 d.	64 d.	27 d.	63 d.	28 d.	62 d.	29 d.	61 d.	30 d.	60 d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1182	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2649	1408	2624	5454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	8	18	10	18	10	18	10	18	10

	31 d.	50 d.	32 d.	58 d.	33 d.	57 d.	34 d.	56 d.	35 d.	55 d.
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	516
4	1028	617	1017	630	1007	653	995	671	983	688
5	1285	772	1272	798	1258	817	1243	838	1228	860
6	1542	927	1526	954	1510	980	1492	1006	1474	1032
7	1809	1081	1780	1113	1762	1142	1741	1174	1720	1204
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2457	1721
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	16	12

	36 d.	54 d.	37 d.	53 d.	38 d.	52 d.	39 d.	51 d.	40 d.	50 d.
1	176	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	541	709	555	699	567	690	578
4	881	705	960	721	945	739	932	756	920	771
5	1213	881	1198	902	1182	923	1165	944	1149	964
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2094	1700	2069	1735
10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
1	8	6	8	6	8	6	8	6	8	16
2	16	12	16	12	16	12	16	12	16	12

	41 d.	49 d.	42 d.	48 d.	43 d.	47 d.	44 d.	46 d.	45 d.	45 d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	888	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1378	1560	1406	1535	1433	1511	1458	1485	1485
8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2036	1772	2006	1807	1974	1842	1943	1874	1910	1910
10	2264	1968	2229	2007	2194	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

The Structure of this Table is from this Ground:

As *Radius* is in Proportion to the Diſtance of two places meaſured in their Rumb: So is the Sine of the Complement of that Rumb, to the Difference in Latitude of theſe two places.

And ſo is the Sine of that Rumb, to the Diſtance of the Meridians of thoſe two places. As, admit I meaſure South-Eaſterly 20 *deg.* 300 Poles, here then the Rumb upon which I meaſure, making with the Meridian an Angle of 20 *deg.* I ſay.

As *Radius* is in Proportion	
to the Diſtance meaſured 300 Poles;	2.47712
So is Sine Complement the Rumb, S E 20 *deg.*	9.97299
to the Difference of Latitude 281$\frac{21}{100}$ *ferè.*	2.45011

Whereby it appears, that the Diſtance of the Parallels of theſe two places is 281$\frac{21}{100}$ Poles; or that the place whereto I meaſure, is more Southerly than the place from which I meaſured, by 281$\frac{21}{100}$ Poles. Now for the Diſtance of their Meridians, ſay,

As *Radius* is in Proportion	
to the Diſtance meaſured 300 Poles;	2.47712
So is the Sine of the Rumb S E 20 *degr.*	9.53405
to their Diſtance in Longitude 102$\frac{606}{1000}$	2.01117

Ch	*Poles.*
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

And thus I find the place whereto I meaſured is more Eaſterly than the place from which I meaſured by 102$\frac{6}{10}$ Poles, and ſomewhat more. And in like ſort may be found all the other numbers expreſſed in this Table; But having thus found for every *degr.* to 45 *degr.* two numbers, the reſt may be deduced from them, as in this Exaumple: 300 Poles at three Poles to the Chain, is an 100 Chains or 10 Changes, finding that in 10 Changes upon this *degr.* the difference Southerly is 281$\frac{2}{10}$ Poles, it muſt for 5 Chauges, which is juſt half ſo much, be almoſt 141; and for one Change, which

which is a tenth part $28\frac{4}{10}$ *ferè*, and so for two Changes twice so much, that is $56\frac{1}{10}$ for three Changes thrice so much, that is, the sum of the two former, namely, $84\frac{6}{10}$, and so by Addition only you may find the rest, as in this Table, which I shall need to prosecute no further. And thus you may take it to the hundredth or thousand parts of a Pole; But this for ordinary occasions, for which it was at first intended, may suffice.

And according to this Example, it will be easie to frame the like Table so a Chain of any other size, or for any other Measure which you use.

It may be objected, That howsoever this Rule holds true in plain Triangles, yet the Triangles here used are neither Plain nor Spherical; for a Plain Triangle is made of three right Lines, and a Spherical of three Arches of great Circles; But in this the three sides are of three several kinds; namely, one side is an Arch of the Meridian, and so of a great Circle; another an Arch of a Parallel, and so of a lesser Circle, the third side or *Hypothenusal* being the Rumb, is no Arch of a Circle, but a Segment of an Helispherical Line.

But I answer, That notwithstanding this may be speculatively conceived, and so demonstrated to be no Plain Triangle; yet in so small Distances as these which here we use, there can be no sensible nor scarce any numerable difference. Yea, the Distance between two Parallels by the Rumb and Distance given (being the thing here chiefly aimed at) is very exactly found by this Rule, as before we have shewed, and as is more fully demonstrated by Mr. *Wright*, in the 12th Chapter of his Book, *Of the Correction of Errours in Navigation*: Whence we may conclude, that the parts of the Meridian collected by this Table according to the Rumbs and Distances, as we have before shewed, do give the true measure of the Segment of that Meridian intercepted, between the Parallels of the two places proposed.

CHAP. IV.

Of the difference of Longitude, Poſition, and Diſtance of York *and* London: *And how the Maps of* England *may by this Experiment be reformed, eſpecially in the Latitude of Places.*

WE come next to ſpeak of the Eaſterly and Weſterly Diſtances gathered, as before is ſhewed by theſe Tables, and to find thereby the Difference of Longitude; and of this we will give an Example in the foreſaid Experiment; whereby we find that the Diſtance in Longitude, or the Eaſt and Weſt Diſtance between *York* and *London* is near 14000 Poles, *London* being ſo much more Eaſterly than *York*. And before we have found that in a *degr.* of the Meridian, and conſequently in a *degr.* of the Equinoctial, there is near $3709\frac{1}{10}$ Chains, at 6 Poles to the Chain, and this 14000 Poles converted into ſuch Chains, is $2333\frac{1}{3}$.

Which $2333\frac{1}{3}$ Chains (for finding the difference of Longitude) are not to be reckoned in the Parallel of *York*, that being too much Northerly: neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both; namely, about the Latitude of 52 *degr* 45 *min.* Now to find what difference of Longitude is anſwerable to this $2333\frac{1}{3}$ Chains in the Parallel of 52 *degr.* 45 *min.* ſay,

As *Radius* is in Proportion

to Sine Complement the Latit. *ſc.* 52 *deg.* 45 *min.*	9.78197
So is the meaſure of a *deg.* in the Equinoctial $3709\frac{1}{10}$	3.56927
to the meaſure of a *deg.* in that Parallel $2245\frac{1}{10}$	3.35124

And

And thus we find that in the Purallel, whoſe Latitude is 52 *degr.* 45 *min.* there are 2245 $\frac{1}{10}$ Chains anſwering to a *degr.* whereby it appears that the difference of Longitude between *York* and *London*, is more than one *degr.* and to find how much more, ſay again by the Rule of Proportion

As the meaſure of a *degr.* 2245 $\frac{1}{10}$ *Co. ar.*	6.64876
is to a *degr.* in *Seconds*, 3600	3.55630
So is the meaſure given, 2333 $\frac{1}{3}$	3.36797
to the number of *Seconds*, 3741	3.57303

Which reduced, is 1 *degr.* 2 *min.* 21 *ſeconds*; and thus we find that *London* doth differ in Longitude from *York* 1 *degr.* 2 *min.* 21 *ſeconds*, being ſo much more Eaſterly.

Thus having the difference of Latitude, as alſo the difference of Longitude between theſe two places, we may (according to the Second Problem of Sailing by *Mercators Chart*) find the Rumb from *London* to *York* to be 14 *degr.* 20 *min.* from the North to the Weſtwards; that is, North and by Weſt 3 *degr.* 5 *min.* Weſterly, and the diſtance in that Rumb 9442 Chains. But their diſtance in the High-way, by reaſon of the crookedneſs and un-evenneſs of it, was more by about an eighth part:

And the like might be done for other intermediate Places between theſe, but affecting brevity, we paſs that over, as not much pertinent to our preſent purpoſe; only expreſſing the Latitudes of ſome of the principal of them, as followeth.

	Latitudes.			
As the Latitude of *York*, we find to be	53	*deg.*	58	*min.*
Doncaſter	53	*deg.*	32	*min.*
Newark upon *Trent*	53	*deg.*	5	*min.*
Grantham	52	*deg.*	54	*min.*
Stamford	52	*deg.*	38	*min.*
Huntington	52	*deg.*	19	*min.*
Royſton	52	*deg.*	3	*min.*
Ware	51	*deg.*	48	*min.*
London	51	*deg.*	30	*min.*

We further noted in this Experiment, that howſoever the number of Miles between *Ware* and *London* are almoſt the ſame by Eſtimation that they are by Meaſure; yet all the way beſides from *York* to *Ware*, a meaſured Mile conſiſting of 320 Poles, is but three quarters of a Mile, as the Miles lie by Eſtimation or common account; ſo that every where (for the moſt part) three Miles by eſtimation make 4 meaſured Miles: and a *min.* or the 60th part of a *deg.* is almoſt in the middle between them both: So that look how much a meaſured Mile is leſs than a *min.* ſo much, or ſomewhat more is a Mile by Eſtimation greater than a *min.* for as there is contained in a *degr.* of meaſured Miles $69\frac{1}{2}$ and ſomewhat more, as we have before ſhewed; ſo of our common eſtimated Miles, there are contained about $51\frac{2}{3}$ in a *degr.*

Upon theſe Grounds the whole Maps of this Kingdom might be much rectifyed, eſpecially in the Latitude of Places; for though we cannot hence determine certainly the Latitudes of any other places beſides thoſe which were in the way, or at leaſt in ſight as we came up (the Principal of which we have before noted.) Yet we may nearly conjecture the Latitudes of moſt parts of *England*, by their Diſtances and Poſitions from theſe; but theſe things being beſides our ſcope and purpoſe in this place, we ſhall only compare the Latitude of ſome principal Places, probably gathered from this Experiment, with the Latitudes of the ſame places, as they are ſet down by Mr. *Speed* in his *Geographical* Deſcriptions of *England*: that ſuch as pleaſe to examine both in any particulars, may know to which they may more ſafely lean.

Canterbury,

	Latitude by this Exper.		Latitude by Mr. *Sp.* Map.	
	D.	M.	D.	M.
Canterbury	51	17	51	29
Chicheſter	50	48	50	51
Guilford	51	12	51	22
Wincheſter	51	03	51	11
Dorcheſter	50	40	50	44
Exceſter	50	43	50	48
Wells	51	12	51	22
Salisbury	51	04	51	12
Redding	51	28	51	42
London	51	30	51	45
Colcheſter	51	58	52	16
Ipſwich	52	08	52	30
Norwich	52	42	53	10
Cambridge	52	12	52	32
Hertford	51	49	52	06
Bedford	52	08	52	30
Buckingham	52	00	52	20
Royſton	52	04	52	24
Oxford	51	46	52	02
Gloceſter	51	53	52	12
Hereford	52	07	52	27
Worceſter	52	14	52	36
Warwick	52	20	52	45

	Latitt. by this Exper.		Latit. by Mr. *Sp.* Map	
	D.	M.	D.	M.
Northampton	52	14	52	36
Huntington	52	19	52	44
Stamford	52	38	53	04
Leiceſter	52	40	53	06
Lincoln	53	14	53	50
Newark upon *Trent.*	53	05	53	38
Nottingham	53	00	53	32
Derby	52	58	53	30
Stafford	52	52	53	22
Shrewsbury	52	47	53	16
Cheſter	53	16	53	52
Lancaſter	54	10	54	57
York	53	58	54	44
Richmond in *York-ſhire*	54	28	55	18
Kingſton upon *Hull*	53	48	54	29
Doncaſter	53	32	54	12
Durham	54	50	55	45
Carlile	55	00	55	56
Newcaſtle	55	03	56	01
Barwick	55	54	57	03

The Latitudes of theſe places in the firſt Column expreſſed, are ſuch as are probably gathered from this Experiment But in the ſecond Column there is ſet down the Latitudes of the ſame places, as they are expreſſed by Mr. *John Speed* in his Map of *England*, ſet forth in his Book, Entituled, *The Theatre of the Empire of Great Britain*; and leſt there ſhould be any miſtake in his Map, I have conferred theſe Latitudes thence gathered, with the Latitudes of the ſame Places, ſet down by him in words at large, in his Deſcriptions of each ſeveral County, and find them nearly to agree, except in the Latitude of *Barwick*, which in his Map he makes to be 57 *degr.* 3 *min.* But in his Hiſtorical Deſcriptions of *Northumberland*, he relates it to be 55 *degr.* 48 *min.* which laſt is much nearer the truth, but ſeems not to be his meaning; becauſe then he ſhould make it more Southerly than *Newcaſtle*, yea, more Southerly than he doth *Carlile*, which by his Map, and alſo by his words in his relation of *Cumberland*, is in the Latitude of 55 *degr.* 56 *min.* whereas *Barwick* is above 50 Miles more Northerly.

By theſe you may nearly conjecture the Latitudes of other parts of *England*, lying in or near the ſame Parallel with any of them: And hence alſo it appears, that the difference of Latitude between *Barwick*, and the South Coaſt of *England* near *Chriſt-Church*, is little more than 5 *degr.* not 6 *degr.* and more, as ſome of our Maps make it. But theſe things we muſt leave, that we may proceed to that which is principally intended, only we will firſt touch a little upon the Uſe of the fore-going Table, in Plotting and Surveying of Land.

CHAP.

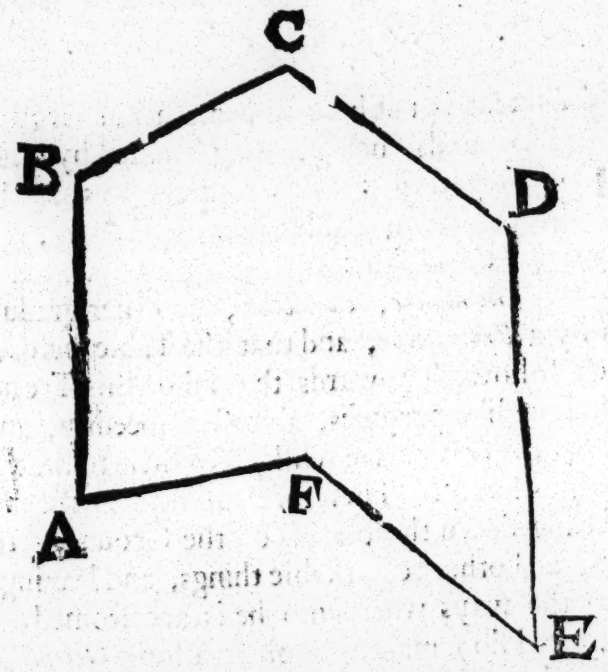
CHAP. V.

To Delineate the Plot of any Forreſt, Park, Common, or other pieces of Ground: as alſo of Rivers, Harbours, &c. ſpeedily and moſt exactly.

MY intent is not here to proſecute at large the Plotting of Grounds, being a thing handled by others, treating of *Surveying*: But conſidering that the ways by them directed, and by others practiſed, in delineating or laying down the Diſtances and Angles obſerved by the *Circumferentor*, *Theodolite*, *Peractor*, or other graduated Inſtrument, is by a *Protractor*, and that the Table before going, or that which followeth towards the end of this Treatiſe, ſerveth for that and the like purpoſes, almoſt as ſpeedily, and far more exactly; I ſhall crave leave to digreſs a little to ſhew this Uſe of it as briefly as I may. Therefore paſſing over the method to be uſed in ſetting down the Names of the Grounds, the Tenants, Borderers, and other remarkable things, and leaving every man in theſe to the ways whereunto he is accuſtomed. You may (as ſometimes I do) make a Book in a long *Octavo*, and upon the left ſide thereof ſet down ſuch things, as theſe before mentioned, reſerving every right ſide, and dividing them by Ruled Lines into 6 Columns; as hereafter following appeareth.

And having taken and ſet down your Notes in the Field on the left ſides or Pages of your Book, you may in the Evening or next morning before you go out, or when elſe your occaſions will permit, ſet down in the firſt Columns on the right ſide, how many *degr.* the Lines upon which you have Traverſed, are diſtant from the North or South part of the Meridian towards the Eaſt or Weſt; and in the ſecond Columns the quantity of the ſame Lines, in Changes, Chains, and ſingle Poles, and parts of Poles.

As in this Figure; ſuppoſe the Line from *A* to *B* to be directly Eaſt 7 Changes, that is, 7 times 30 Poles, or 210 Poles, from *B* to *C* to the Eaſtwards of the South 35 *degr.* 8 Changes, and 1 Chain, from *C* to *D*, to the Weſtwards of the South 32 *degr.* 5 Changes, and 4 Chains, from *D* to *E* to the Weſtwards



of the South 80 *degr.* 10 Changes, from *E* to *F*, to the Eaſtwards of the North 35 *degr.* 6 Changes, 3 Chains, and two thirds of a Pole. And laſtly, from *F* to *A*, the place where I firſt began, to the Weſtwards of the North 9 *degr.* 5 Changes, 3 Chains, 2 ½ Poles: All theſe I expreſs in the firſt and ſecond Columns on the right ſide, as hereafter following appeareth.

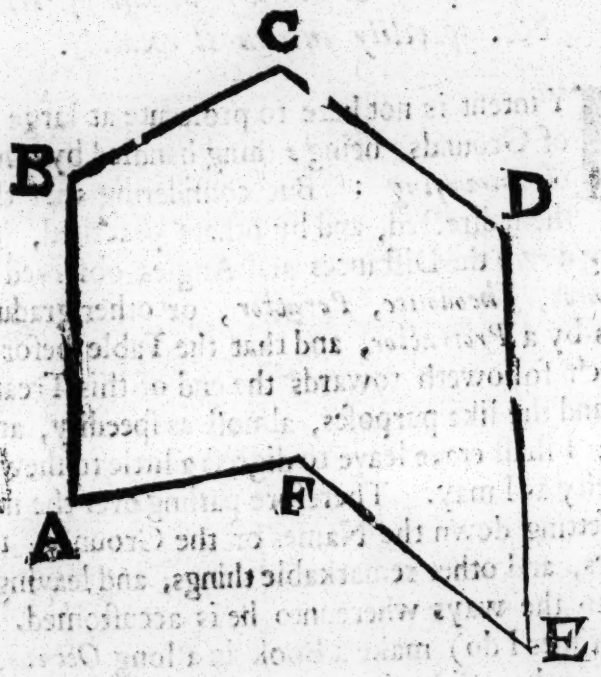
Which done, I take the Table, and find there the Northing and Southing, Eaſting or Weſting anſwerable to theſe *degr.* and Diſtances, and ſet them down accordingly. As for the firſt being Eaſt 7 Changes, I ſet down in the Eaſt Column 210 Poles with

with a Cypher behind it. For the ſecond being *S E*, 35 *degr.* I find in the Table for 5 Chains 1228, to be ſet in the South Column, and 860 for the Eaſt Column, alſo upon the ſame *degr.* for 1 Chain 25 for the South Column, and 17 for the Eaſt Column; and ſo I proceed with all the reſt, until I have finiſhed.

Deg.		*Diſtance.*	*North.*	*South.*	*Eaſt.*	*Weſt.*
Eaſt.					2100	
S E	35			1228	0869	
				0025	0017	
S W	32			1272		
				0102		0795
S W	80			0521		0064
						2954
N E	35		1474		1032	
			0074		0052	
			0005		0004	
N W	09		1481			0234
			0089			0014
			0025			0004
			3148	3148	4065	4065

And being thus returned to my firſt Station, I ſum up ſeverally theſe 4 Columns of North, South, Eaſt and Weſt; and finding that the ſum of the North Column is equal to that of the South, and the ſum of the Eaſt is equal to that of the Weſt, I conclude the whole Work to be truly performed, whereas if there had been any difference, it had ſhewed an Errour; and if that difference had been great, it had been neceſſary to examine the Work again, and ſo correct it.

As in this Figure; ſuppoſe the Line from *A* to *B* to be directly East 7 Changes, that is, 7 times 30 Poles, or 210 Poles, from *B* to *C* to the Eaſtwards of the South 35 *degr.* 8 Changes, and 1 Chain, from *C* to *D*, to the Weſtwards of the South 32 *degr.* 5 Changes, and 4 Chains, from *D* to *E* to the Weſtwards



of the South 80 *degr.* 10 Changes, from *E* to *F*, to the Eaſtwards of the North 35 *degr.* 6 Changes, 3 Chains, and two thirds of a Pole. And laſtly, from *F* to *A*, the place where I firſt began, to the Weſtwards of the North 9 *degr.* 5 Changes, 3 Chains, 2 ½ Poles: All theſe I expreſs in the firſt and ſecond Columns on the right ſide, as hereafter following appeareth.

Which done, I take the Table, and find there the Northing and Southing, Eaſting or Weſting anſwerable to theſe *degr.* and Diſtances, and ſet them down accordingly. As for the firſt being Eaſt 7 Changes, I ſet down in the Eaſt Column 210 Poles

with

with a Cypher behind it. For the second being *S E*, 35 *degr.* I find in the Table for 5 Chains 1228, to be set in the South Column, and 860 for the East Column, also upon the same *degr.* for 1 Chain 25 for the South Column, and 17 for the East Column; and so I proceed with all the rest, until I have finished.

Deg.		*Distance.*	*North.*	*South.*	*East.*	*West.*
East.					2100	
S E	35			1228	0869	
		5		0025	0017	
S W	32	1		1272		
		4		0102		0795
S W	80	10		0521		0064
		0				2954
N E	35	3	1474		1032	
		2	0074		0052	
		0 3	0005		0004	
N W	09	1	1481			0234
		3	0089			0014
		2 1/2	0025			0004
			3148	3148	4065	4065

And being thus returned to my first Station, I sum up severally these 4 Columns of North, South, East and West; and finding that the sum of the North Column is equal to that of the South, and the sum of the East is equal to that of the West, I conclude the whole Work to be truly performed, whereas if there had been any difference, it had shewed an Errour; and if that difference had been great, it had been necessary to examine the Work again, and so correct it.

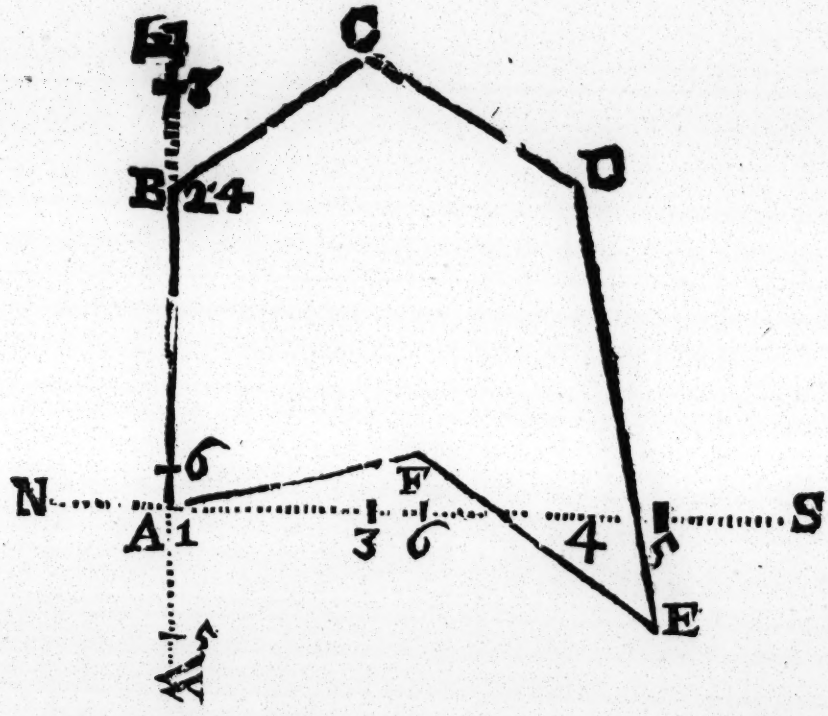
It is usual to add together all the Angles, and also to multiply two right Angles, or 180 *degr.* by the number of Angles lacking two; and if the Sum of the Angles added together, be equal to the Product, the Work is thought to be true: as here, if we add the Inclinations and Reclinations of these Lines in this Figure, the Sum is 720 *degr.* or 8 right Angles; and if we multiply two right Angles by 4, (because here are 6 Angles) the Product is also 8 Right Angles. But the other by the Sums of the Columns, is a most absolute way for examining the truth of your Work, and to be preferred before any other that I know.

It may seem very laborious to set down every Station in this manner, but one that is a little exercised in it may, as I take it (for I never observed the time exactly) set down 40 or 50 Stations in this manner, within the space of an Hour, or thereabouts: But I should advise that it be done by two Men, having each a Table for that purpose to avoid all mistakes.

If your Instrument give not the Angle with the Meridian expressly, yet it may easily be gathered thence, or else you may Divide a Circle as your Instrument is Divided, and number the *degr.* as they are there numbred; which done, number them also from the N. and S. part of the Meridian towards the E. and W. so shall you easily know the Angle of any *deg.* with the Merid.

Now to proceed, these measures may be set down in a Plot several ways. As first, considering which way the Ground lies, I take a Point for my first Station, so as the whole may fall conveniently within the Plot, which let be the Point *A*, by which Point I draw a Meridian & Parallel, namely two right Lines intersecting one another at right Angles: whereof let *N S* be the Meridian running North and South, and *E W* the Parallel running East and West; this done, I look to the North and South Columns, and there first in the South Column, and against the third Station, I find 1253, that is, $125\frac{3}{10}$ Poles, this I set in the Meridian from *A* to the Southwards, and mark the Point with the Figure 3; then in the South Column against the fourth Station, I find 1374, which I set in the Meridian from 3 to 4: also against the first Station I find 521, which I set in the Meridian

dian from 4 to 5. Then againſt the Sixth Station, I find in the North Column 1553, which I ſet in the Meridian from 5 to 6: alſo againſt the Seventh Station, which is the ſame with the Firſt, I find 1595, which I ſet in the meridian from 6, and it falls upon *A*, which is the firſt Station: and thus I have done with the South and North Columns,



In like ſort I expreſs the meaſures in the Eaſt and Weſt Columns in the Parallel *E W*. As finding firſt in the Eaſt Column 2100, I ſet it down from *A* to the Eaſtwards, and it extends to *B*, where I ſet 2, ſignifying my ſecond Station; I find next in the Eaſt Column 877, which I ſet in that Parallel from 2 to 3, next in the Weſt Column 859, which I ſet in that Parallel from 3 to 4: and ſo I proceed with the reſt. And having thus ſet down the meaſures in the Meridian and Parallel, we have alſo as it falls out in this Example two Stations expreſs'd, namely *A* and *B*,

now

now for the third; I take in the Parallel with my Compaſſes the diſtance *A* 3, and ſetting one Foot in the Meridian at 3, I ſtrike an Arch near *C*; alſo taking in the Meridian the Diſtance *A* 3, and fixing one Foot in the Parallel at 3, I croſs the foreſaid Arch near *C*, the interſection of theſe two Arches is the Point *C*, repreſenting the third Station.

In like ſort, I proceed to find the Points *D E F* for the fourth, fifth, and ſixth Stations; then drawing Lines, namely from the firſt Station *A* to the ſecond *B*, and from the ſecond to the third *C*, *&c.* We ſhall deſcribe the Figure required *A B C D E F*.

Otherwiſe, whereas here you Add and Subſtract the ſeveral Diſtances of South and North, as alſo of Eaſt and Weſt by your Compaſſes; you may with a little more pains Add and Subſtract them by the Pen, which is the better way.

As having ſet down in the Meridian the Southerly diſtance of the third Station 1253, I add thereto 1374, which is againſt the fourth Station, the ſum is 2627; the Southerly diſtance of the fourth Station, which I ſet in the Meridian from *A* to 4. Again, to this I add 521, ſo have I 3148, the Southerly diſtance of the fifth Station *A* 5, from which Subſtracting 1553, the Northerly diſtance ſet againſt the ſixth Station, there remains 1595, which is the Southerly diſtance of the ſixth Station, to be ſet in the Meridian from *A* to 6. Laſtly, from this, abating the Northerly diſtance of the firſt Station from the ſixth, which I find there alſo to be 1595, there remains 0. Shewing that I am returned to the ſame Parallel, or Eaſt and Weſt Line, in which at firſt I began. And in like ſort, you may proceed with the Eaſt and Weſt Columns, and then by the Interſection of two Arches, find every Station as before.

Other ways might be preſcribed, which will not be hard to find of your ſelf. And as we may thus lay down any irregular right-lined Figure far more exactly than by the *Protractor*: So when it is laid down after this manner, we may caſt up the *Area* or ſuperficial quantity of it very exquiſitely: Yea, if there ſhould be a Plot drawn (according to the Angles and Diſtances here given) after the uſual manner by a Scale ſo large, that the

Plot

Plot ſhould be an hundred times ſo great as this; Yet could not the Content thereof be caſt up ſo exactly and certainly as it may be here.

But I muſt not inſiſt upon theſe things, they may of themſelves be conceived, and my intent is only to touch them, that I be not prevented of time, and by other occaſions from handling thoſe things which I have here more ſpecially intended.

But as I have ſaid, this courſe is chiefly to be uſed in Plotting large Grounds, and there indeed are graduated Inſtruments, eſpecially to be uſed: for other ſmaller Grounds, there is none more fit then the *plain Table*.

CHAP. VI.

Of the Compaſs of the Earth, and the quantity of a Degree, according to the moſt approved Experiments Ancient and Modern.

ALthough tne Compaſs of the Earth hath been in ſome ſort obſerved by divers of the Ancients: Yet for ſome of them we cannot certainly gather what meaſures they uſed; others uſed no meaſure at all, but aſſumed the Diſtance of places to be ſuch as it was eſtimated by Travailers to be, and likewiſe the Latitude; therefore it will be needleſs to inſiſt upon the examination of their Obſervations; others of them which were taken by meaſure, and which we may upon any good Ground reduce to our meaſures, are theſe which follow.

Willebrordus Snellius in his Book Entituled *Eratoſthenes Batavus*, cites *Abel Fedas*, a moſt diligent *Arabian* Geographer, that lived about the year of Chriſt 1322, who records, that about

about the year of Chriſt 827, certain Men skilful in the *Mathematicks*, did by the commandment of their Prince *Almanon*, meaſure in the Fields of *Meſopotamia* (as he gathers) under one and the ſame Meridian, from the North towards the South, the quantity of a *degr.* and found it to be 56 Miles, or ſomewhat more. The quantity of their Mile, according to *Alphraganus*, was 4000 Cubits, or 6000 Feet, whence the quantity of a *deg.* ſhould be 336000 Feet; but of the length of their Feet we are ſomething uncertain; only they define it to be ſo long as the extent of 96 Barley Corns laid ſide by ſide; whereas the *Rhynland*-foot, according to tryal by him made, is but the extent of 90 Corns laid in like manner, ſo that if there be no inequality in the Grains, then 90 *Arabian* Feet are equal to 99 *Rhynland*-feet. But 96 *Rhynland*-feet are found to be about $91\frac{1}{6}$ *Engliſh* Feet; therefore alſo, by the Rule of Proportion, 336000 *Arabian* Feet do make of our *Engliſh* Feet 370222. So that according to this experiment of the *Arabians*, a *degr.* ſhould contain 370222 of our *Engliſh* Feet. And before we have found by the Obſervations taken at *London* & *York*, and by the diſtance of their Parallels meaſured, that a *degr.* contains of our *Engliſh* Feet 367200. The difference is only 3022 Feet, that is, about the $\frac{1}{120}$ part of a *degr.* or half a *min.*

He cites next *Alhazen* the *Arabian*, who in his Book *de Crepuſculis*, declares the Compaſs of the Earth to be 24000000 Paces; ſo that proportionally there muſt be in one *degr.* $66666\frac{2}{3}$ Paces, that is 333333 *Arabian* Feet. And ſeeing that 90 *Arabian* Feet make of our *Engliſh* Feet $99\frac{1}{6}$, therefore by the Rule of Proportion 333333 *Arabian* Feet, make of our *Engliſh* Feet 367283: So that according to *Alhazen*, there ſhould be in a *degr.* 367283 of our *Engliſh* Feet, differing from the Experiment which I made only 83 Feet in a *degr.*

I have not ſtrained theſe numbers to bring them to this nearneſs, they are the ſame in effect which are ſet down by *Snellius* in his *Eratoſthenes Batavus*, who with great Induſtry and Judgement hath compared the meaſures of the Ancients, and the meaſures uſed by ſeveral Nations in theſe times, with the

Rhyn-

Rhyniand-foot. Much leſs have I ſtrained my own numbers to draw them up to theſe: But on the contrary, I confeſs upon the ſight of his Book, obſerving the great pains and induſtry which he profeſſeth himſelf to have beſtowed, and which I doubt not but he did imploy in making his Experiment, and how he had found the meaſure of a *degr.* to be much leſs than mine, as we ſhall after ſhew, I began to doubt that I had not made ſufficient allowance for the un-evenneſs of the ways, and for ſome ſmall bendings, ſometimes to the right hand, ſometimes to the left, the Obſervation whereof I wittingly neglected, to ſpare time and Expence. For I did often obſerve a Mile or two before me, ſome Mark in the High-way noting the *deg.* and meaſuring to it in the way, neglecting to obſerve the intermediate ſwerving of the way, ſometimes three or four *degr.* towards the right hand, ſometimes as much to the left; but making ſuch allowance for that, and for the un-evenneſs as I judged ſufficient. And ſome Men may think, that the exact Obſervation of theſe leſſer things thus neglected, and regulated only by judgement or conjecture, might deceive me much: But they may conſider, that if there be two places a Mile diſtant, that is, in a right Line 320 Poles, if you meaſure from one of theſe places towards the other, not in that right Line, but always ſwerving from it by an Angle of four *degr.* ſometimes to the right hand, ſometimes to the left, till you come to that other place; I ſay, that notwithſtanding all theſe ſwervings (if there be nothing elſe to augment the meaſure) it will not amount to 321. Now conſidering that I had all the way, as occaſion required, made ſuch allowance as ſeemed convenient, and ſo found 367200 Feet in a *degr.* before I compared it with the meaſures taken by another: I reſolved not to diminiſh nor to augment the number thus ariſing by my Obſervations, Meaſures, and Allowances, in reſpect of the Opinions, Obſervations, or Meaſures of any other Man, until there be made ſome Experiment more evident and exact than any yet extant. And I am ſomething the more confirmed by the near agreement of theſe two teſtimonies before recited, both exceeding me a little in the meaſure of a *deg.* But we cannot confi-

dently reſt upon them, becauſe of that inequality which may be of Corns or Grains; for theirs may haply be ſomething greater or leſſer than ours.

Both theſe meaſures of a *degr.* do much exceed the quantity of a *degr.* found by *Snellius*, but when he compares them with his own another way, namely, placing the Barley-Corns ſo that they may not lie flat, but be ſet up edge-wiſe, and ſo by 96 Corns to make a Foot, and by ſuch Feet to meaſure a *degree*; then he finds that the quantity of a *Degree*, according to the *Arabians*, is much leſs than by his Experiment it ſhould be: but if ſome be laid flat, and others ſet up edge-wiſe, the *Arabian* meaſure of a *degr.* will agree with his. And ſo he propoſeth this doubt, whether the 96 Grains, whereof the *Arabian* Foot doth conſiſt, muſt lie flat or be ſet up edge-wiſe, or ſome of them to lie flat, and others to be ſet up edge-wiſe. But it is moſt probable that they muſt lie flat, that being the poſition which they are apt unto by nature; they cannot be ſet edge-wiſe without much trouble, eſpecially ſo many together as make the length of a Foot, and ſo the *Arabian* meaſure of a *degr.* doth nearly agree to this of mine.

We come next to hear the determination of *Ptolomy* of *Alexandria*, whoſe authority and credit in the ſolution of this queſtion, is not inferiour to any of the Ancients. He affirms the Compaſs of the Earth to be 180000 *Stadiums*, and the quantity of a *degree* 500 *Stadiums*; the ſame (as *Strabo* ſaith in his ſecond Book of *Geography*) was before affirmed by *Poſidonius*. Alſo *Marinus Tyrius* (before *Ptolomy*) had determined the quantity of a *degr.* to be 500 *Stadiums*. *Ptolomy* confirms it, not ſimply from their relations, but as it ſeems from his own experience, and that by ſome meaſures diligently taken, for in the 11 Chap. of the firſt Book of his *Geography*, he hath theſe words; *Sed in hoc quoque recte ſentit, partem unam qualiam eſt circuli maximus tricentorum ſexagintâ; quingenta in terra conſtituere Stadia, id enim confeſſis dimenſionibus conſonum exiſtit.* Alſo *lib.* 7. *cap.* 5. *Ita ut pars una, ſeu gradus unus quingenta contineat Stadia, quemadmodum ex diligentibus deprehenſum eſt dimenſionibus.*

Now

Now a *Stadium* not only among the *Greeks*, but as appears by *Herodotus* amongſt all other Nations of *Aſia* and in *Ægypt*, did conſiſt of 600 Foot: therefore a *Degree* according to *Ptolomy*, muſt contain 300000 Feet. But the *Ægyptian* or *Alexandrian*-Foot was much greater than our Foot; for as we have before ſaid, the ancient *Roman* Foot is greater than ours, and the *Ægyptian*-Foot was much greater than the *Roman*: For it is often teſtifyed by *Hero Merchanicus*, that 5 *Alexandrian*-Feet make 6 *Roman*-Feet. And Mr. *Snellius* hath very ingeniouſly gathered both from *Philandes* and otherwiſe, that the *Rhynland*-Foot is equal to the ancient *Roman*-Foot; therefore alſo 5 *Alexandrian*-Feet are equal to 6 *Rhynland*-Feet: So that by the rule of Proportion, 300000 *Alexandrian*-Feet, will make of *Rhynland* Feet 360000. But by the ſize of our *Engliſh*-Foot, which was ſent him from the Iron Standard in *Guild-hall*, he finds it to contain but 968 ſuch parts as the *Rhynland* contains 1000: So that 968 *Rhynland*-Feet are equal to 1000 *Engliſh*, or 121 *Rhynland*-Feet are equal to 125 *Engliſh*-Feet. Therefore alſo by the Rule of Proportion, 360000 *Rhynland*-Feet are equal to 371900 of our *Engliſh*-Feet. Therefore according to *Ptolomy*, there are contained in a *degree* 371900 of our *Engliſh* Feet. But by our fore-mentioned Experiment made between *York* and *London*, we find only 367200 Feet in a *degree*, being leſs than *Ptolomies* by 4700 Feet, that is, by $\frac{1}{80}$ part of a *degr.* or $\frac{3}{4}$ of a *min.* and little more.

Fernelius a Modern Author and Learned Phyſician, meaſuring the way by Revolutions of a Wheel, and the Latitudes by Obſervation, finds in a *degr.* 68 *Italian* Miles, and 96 Paces, the Pace which he uſed being more than $\frac{5}{6}$ of our *Engliſh*-Feet: But becauſe he handled not the Problem exactly, and is ſuſpected by *Snellius* (though I think without cauſe) to have grounded his Concluſion rather upon the Experiment of the *Arabians* before ſet down (wherewith it doth nearly agree) than upon his own, we will inſiſt no longer upon it.

We come in the laſt place to the Experiment of *Willebrordus Snellius*, a *Hollander*, made in the *Netherlands* about 20 years

paſt. We ſhall not need to recite the particulars of it, being extant at large in his Book before mentioned: but in Concluſion, he finds in a *degr.* 342000 *Rhynland*-feet. Now a *Rhynland*-foot (as he hath there ſhewed, comparing both together) is greater than ours, and that in ſuch proportion, as 1000 is to 968, (and ſo much or little more it appears to be by that model of the *Rhynland* foot Printed in his Book) therefore 968 *Rhynland*-feet muſt make 1000 of ours; and hence by the rule of Proportion, 342000 *Rhynland*-feet, will make of our *Engliſh*-feet 353306. So that there ſhould be in a *degr.* only 353306 feet, which is leſs than we have before found in a *degr.* by 13894 feet, that is, by $\frac{1}{10}$ part of a *degr.* or $2\frac{1}{4}$ *min.* and ſomething more. He was a man doubtleſs of ſingular Induſtry and Knowledge, and of much exerciſe in the *Mathematicks*, and it may be, was well experienced in this particular, touching the *Geometrical* menſuration of Diſtances, and he hath beſtowed much pains and diligence in this Experiment, as by his Book appeareth. But if he had by a Chain meaſured the Diſtance of his two utmoſt Stations (if the Ground would permit, which I ſuppoſe it would not) or at leaſt-wiſe if his meaſured Stations had been further diſtant: I conceive he would have found a greater Diſtance in his two utmoſt places of Obſervation. But if a man, intending to find the Diſtance of two places, meaſure only the $\frac{1}{100}$ part of that Diſtance, and by that meaſured Line and the Angles, think to find their true Diſtance; whether he do it immediately from thoſe two meaſured Stations, or mediately by help of others obſerved from them, he may eaſily fall into ſome notable Errour. For though the Problem be exactly true in Geometrical Demonſtrations, how ſmall ſoever the meaſure be, yet it is not ſo in ſenſible and experimental Practices, by reaſon of the weakneſs even of the beſt Eye, and the imperfection of the Inſtruments in themſelves, and in their uſe. And beſides that, there were many Stations obliquely ſituate; A man cannot always hit the juſt middle of that Turret, Steeple, or other mark which he obſerves: Neither when he comes to make his Station there, can he always place his Inſtrument juſt at the concourſe of his former viſual Lines,

Lines, by reaſon of other Impediments. Beſides the force of the wind in ſuch eminent places: and moreover, that amongſt ſo many Steeples as there are in ſome Towns, there, a man may at ſome time miſtake one for another. And if there ſhould happen no notable Errour, by reaſon of any or of all theſe Caſualties: Yet may two *min.* in the difference of the Latitude of two places be eaſily miſtaken, eſpecially being derived from the Latitudes of thoſe places which are very rarely ſet down true to a *min.*

If it be objected, that I might aſwel be ſo much miſtaken in the difference of the Latitudes of *York* and *London.*

I anſwer, it is not ſo likely, becauſe I had the opportunity of obſerving the Summer Solſtitial Altit. of the Sun in both places, wherein I had no neceſſary uſe of the Suns Parallax nor Refraction, nor of the Table of the Suns Declination, any of which may cauſe more than a *min.* Errour, in finding the Latitude of either place.

Beſides, if mine Errour in thoſe Obſervations ſhould be full as much, yet would it not in the Concluſion be half ſo much, becauſe the difference in Latitude of the two places of my Obſervation is more than twice ſo much as that of his.

But let this ſuffice, leaving every man to embrace that which he ſhall beſt approve. Both our Experiments do ſufficiently convince that common Error of counting only 300000 *Engliſh*-feet to a *degr.* beſides the conſent of other Obſervations before recited Ancient and Modern.

M. *Snellius* hath further in that Book of his, Entituled *Eratoſthenes Batavus*, with much diligence compared ſome Ancient meaſure, as alſo the meaſures of ſundry Forreign Contreys with the *Rhynland*-foot; and amongſt the reſt, our *Engliſh*-foot, according to a ſize thereof to him ſent from the *Standard* in *Guild-Hall*, (from whence alſo I had about 20 Years paſt, the ſize of that Foot, which I have uſed in this meaſure,) we ſhall not need to repeat them all, becauſe his Book is extant: Some of them are theſe following, which we here compared to our *Engliſh*-foot, as he hath there done to the *Rhynland*, that ſo any of them may the more eaſily be reduced into our Feet. Therefore dividing

the

the *Engliſh*-Foot into 1000 equal parts, we ſhew how many of thoſe parts are contained in other Ancient and Forreign Feet.

Ancient Feet compared with our *Engliſh*-Foot.

Of ſuch parts as the *Engliſh*-Foot contains.		1000
The	Ancient *Roman*-Foot contained,	1033
	Ancient *Greek*-Foot contains	1076
	Babylonian contains	1211
	Alexandrian contains	1240
	Antiochean contains	1405
	Arabian contains	1102

Forreign Feet compared with our *Engliſh*.

Of ſuch parts as the *Engliſh*-Foot contains.		1000
The	*Rhynland*-Foot contains	1033
	Dort-Foot contains	1085
	Middlebrough-Foot contains	992
	Amſterdam-Foot contains	934
	Antwerp-Foot contains	939
	Lovain-Foot contains	939
	Hafnian-Foot in *Denmark*	965
	Paris-Foot called the *Kings*-Foot	1090
	Venice-Foot	1157
	Toledo-Foot	896
	Nurimberg-Foot	1006
	Straitsburg-Foot	920

CHAP. VII.

Of dividing the Log-line, *and reckoning the Ships way.*

THere be four things, upon which the Practice of *Navigation* is eſpecially grounded; namely, the knowledge of the Longitude, Latitude, Courſe, and Diſtance. Touching the Longitude, thouph it may be found by the other

other three, yet hitherto there hath not been delivered any general Rule true and practicable, whereby the Longitudes of places might be immediately and ordinarily found of themſelves. The Latitudes of places may immediately be found by Obſervation of the Sun and Stars; as we have formerly ſhewed in the Appendix to the *Doctrine of Triangles*: The Courſe by the Compaſs, the Variation being duly obſerved, wherein we have many good Mariners very expert, this we have alſo handled in the *Doctrine of Spherical Triangles.* The Diſtance run is found of it ſelf by the *Log-Line*, whereof we are here to ſpeak.

The ground of finding the Diſtance run by the *Log-Line* is meerly conjectural, being founded upon this Opinion, that 5 of our Feet make a Pace, and 1000 ſuch Paces make a Mile, and that 60 ſuch Miles make a *Degree*; ſo that a *Degree* ſhould contain 300000 of our Feet: But it appears not only by this Experiment, but even by all others that were diligently taken, and their meaſures to us known, that there is a greater number of our Feet contained in a *Degree.*

There be three things (as I conceive) that have cauſed this Errour to be ſo commonly received and tollerated. The one, for that it doth ſomewhat counterpoiſe another contrary Errour in the Practice of *Navigation*: namely, in the uſe of the *Plain Chart*; for the Errour which is there committed by making every Parallel equal to the Equinoctial, and ſo every *Degree* in them greater than they ſhould be', is ſomething moderated by this Errour; whereby the meaſure of a *Degree* is eſteemed leſs than indeed it is.

For Inſtance; It is evident by the *Globe*, that the Meridians concurring in the Poles grow nearer and nearer together, as they grow towards the Poles; Inſomuch, as if two Meridians be diſtant in the Equinoctial 10 *Degrees*, that is, 600 Miles, the ſame Meridians in the Latitude of 35 *Degr.* will be diſtant little more than 490 Miles. Now if unto every Mile we account according to the former Experiment 6120 feet, then is the diſtance of thoſe 2 Meridians in that Parallel near 3000000 feet. In like ſort in the *Plain Chart* 10 *deg.* of that Parallel (as of all others) is made

equal

equal to 10 *degr.* of the Equinoctial or Meridian: ſo that the Diſtance of theſe two Meridians will upon the *Plain-Chart* be 600 Miles, but one of theſe Miles contains only 5000 feet, ſo that the Diſtance is but 3000000 feet, equal to the former.

And although theſe Errors in other caſes do not juſtly ballance one another, as in this Example, yet that of the *Plain-Chart* is always ſomething moderated by this other, and ſo much the more by how much they are nearer to the foreſaid Latitude. I grant that this is only ſo, when the Courſe is near unto the Eaſt or Weſt Points; but withal, I ſay that this kind of reckoning is (in a manner) then only uſed: For he that runs any Courſe near the Meridian Southerly or Northerly, hath a more certain way of reckoning; namely, his Latitude, which he finds daily by Obſervation of the Sun and Stars, upon which he will depend, either neglecting, or at leaſt not regarding his dead reckoning. Yea, (if it may be) never caſting the *Log* ſo much as once in ſuch a Voyage, having a more ſure ground for his reckoning. But in a Courſe that is near the Eaſt and Weſt, (foraſmuch as there is no way diſcovered for finding the Longitude) he is driven of neceſſity to make uſe of his dead reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of thoſe which conſiſt of Courſes much Eaſterly and Weſterly, as to and from the *Weſt-Indies*, and the Parallel of *Cape bon Eſperance* are near unto this Latitude of 35 *degr.* ſo that as ſome of them are more Southerly, others of them are more Northerly.

But to inſiſt no longer upon this, I ſuppoſe a ſecond cauſe to be, for that Men commonly deſire to have their reckoning before their Ship (as they ſay) that they fall not with a place before they look for it; And this comes ſo to paſs, whilſt the Miles are accounted leſs in meaſure, and ſo more in number than they are indeed.

And thus, though there may ſeem to be ſome commodity in theſe Errours, eſpecially when they do nearly ballance one another: Yet becauſe they ſeldom do ſo, but always leave men in uncertainties, and oftentimes in great perplexity and danger, it

is

is much ſafer and better to reject them both, and to imbrace thoſe ways, which are evidently grounded upon truth, though there may be in them ſome more difficult at the firſt. Yet I confeſs, that he which reforms one and not another, may ſometimes erre ſo much the more thereby. And I doubt not, but many would reform them both, if they could certainly do ſo.

Therefore a third cauſe of admitting and retaining this Error ſeems to be, for that there hath been no way delivered from evident and certain Grounds for the rectifying of it. I doubt not but many have found Errours in their Reckonings ariſing from hence, that they account only 300000 of our Feet to a *degree*; but not knowing certainly where to lay the fault, have imputed it ſometimes to ill Steerage, otherwiſe to the Variation of the Needle, or to ſome miſtake in the Reckonings, or to ſome error in their Plots, or to ſome Current, or ſuch other accident, and ſo the Errour hath reſted unreformed. Wherefore although the practical performance of this Problem for finding the Circumference of the Earth, or the quantity of a *degree* on the ſame, have many ſingular uſes which I cannot now touch; yet that which amongſt the reſt I chiefly aimed at, was, that we might have a more ſure and evident ground for dividing the *Log-line*, and for reckoning the Ships way or diſtance run more truly upon any Rumb or Point of the Compaſs than formerly.

And now to apply it to this purpoſe, we have noted before (*Chap.* 2.) that by the experiment there expreſſed, we find in a *Degree* on the Circumference of the Earth and Sea, 367200 of our *Engliſh*-feet. Wherefore retaining ſtill the ſame diviſion of a *degree* into 60 miles or 20 Leagues (as hath been formerly uſed) a Mile will contain 6120 Feet, or 1020 Fathoms: And ſo a League contains 18360 Feet, or 3060 Fathoms; for dividing 367200 by 60, the Quotient is 6120, *&c.* Thus then 60 Miles being a *degree*, every Mile is 6120 Feet.

Now ſuppoſing the time of the running out of the *Log-line* to be meaſured by an half Minute-glaſs, if we obſerve how many Feet or Fathom ſhe runs in a half Minute; we may thereby find her way for an hour or 4 hours, or for any other time propoſed.

As admit there runs out of the *Log-line* in half a minutes ſpace 51 Feet, or 8½ Fathoms, and you would know what way the Ship makes every hour after the ſame ſame rate;

Say by the Rule of Proportion;

If 0½ Minutes, give 51 Feet,

What gives 60 Minutes; Or,

If 1 Minute gives 102 Feet:

What gives 60 Minutes?

And ſo Multiplying, you ſhall find 6120 Feet, which is one Mile. Or, if you would find her way for 4 hours, which is 240 minutes; ſay,

As 1 minute, is in proportion to 240 minutes,

So are 102 Feet, to 24480 Feet, or 4 miles.

Or if you would have it in Fathoms; ſay,

As 1 minute is in proportion to 240 minutes;

So is 17 Fathoms, to 4080 Fathoms, the Ships way in four hours. The like is to be conceived, if your Glaſs be for any other quantity of time above or under half a minute.

Some have thought that the way which the Ship maketh, may be known to an old Sea-man by experience (as they ſay) that is, by conjecture: Which Opinion makes ſome neglect the uſe of the *Log*, leſt they ſhould be accounted young Sea-men. But as he that rides often will have ſome near gueſs how far the pace he rides will carry him in an hour (becauſe he hath often obſerved it formerly) ſo he which hath often Sailed and kept an account of the Ships way by the *Log*, will be able to give ſome near eſtimate of her way without the *Log*. But it is incident to ſome men to have ſuch a conceit of this their eſtimate, that they think it more certain than the Rule it ſelf, from whence it is derived, eſpecially if it chance to anſwer their expectations at ſome times.

It is thought alſo that the Ships way may be known by two Marks on the Ships ſide, but this is doubtleſs very uncertain, both by reaſon of the ſhortneſs of the time, and in reſpect of the dead water (as they call it) by the Ships ſide. For the water which is near the Ship, is drawn along with the Ship in her

her motion, and ſo much the more, by how much it is nearer.

But if any deſire to make tryal of this way, it is to be conſidered, that 17 Foot is $\frac{1}{3\,6\,0}$ part of a mile, and 10 *ſec.* of a minute is $\frac{1}{3\,6\,0}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 17 Feet, if the Ship run the diſtance of theſe two Marks in 10 *ſec.* ſhe runs a mile an hour, if in 5 *ſec.* two miles an hour, if ſhe runs that diſtance in 2 *ſec.* ſhe runs 5 miles an Hour. And ſo always dividing 10 *ſec.* by the number of *ſec.* in which the Ship runs in that diſtance, the Quotient ſhews the miles and parts of a mile run in an hour.

But if the diſtance of thoſe two Marks be 34 Feet, if ſhe run it in 20 *ſec.* it is after a mile an hour: if in 10 *ſec.* two miles an hour, if in 5 *ſec.* four miles an hour: and ſo always dividing 20 *ſec.* by the number of *ſeconds*, in which the Ship runs that diſtance, the Quotient ſhews how many miles the Ship runs in an hour. As if the Ship run that diſtance of 34 Feet in 8 *ſec.* then Dividing 20 by 8, the Quotient is $2\frac{1}{2}$, ſhewing that ſhe runs $2\frac{1}{2}$ miles in an hour. Or, if you can conveniently make the diſtance of the two Marks on the Ships ſide to be 51 Feet (for the further they are diſtant, the better) then if the Ship run that diſtance in 30 *ſec.* it is a mile an hour, if in 10 *ſec.* it is 3 miles an hour, and ſo always dividing 30 *ſec.* by the number of *ſeconds*, in which the Ship is running that diſtance, the Quotient ſhews after that rate how many miles the Ship runs in an hour.

Otherwiſe you may do thus, Divide 17 Feet into 10 parts, and ſet as many of thoſe parts on the Ships ſide, as conveniently you may, (which according to the Ships length will be more or fewer.) Then when the Ship runs one of thoſe parts in a *ſec.* of time, it is a mile an hour: when two, it is two miles an hour; when 5, it is 5 miles an hour. And in general, if you divide the number of parts run by the time of running accounted in *ſec.* the Quotient ſhews what number of miles after that rate are run in an hour.

As if ſhe run 30 of thoſe parts in 5 *ſeconds*, it is 6 miles an hour; for dividing 30 by 5, the Quotient is 6; ſo if ſhe run 42 of thoſe parts in 10 *ſeconds*, dividing 42 by 10, the Quo-

tient is $4\frac{2}{10}$, which ſheweth the Ships way at that time to be after the rate of four Miles and two tenths of a Mile in an hour.

But for keeping this account of time, it may be done either by a Sand-glaſs for that purpoſe, or by pronouncing certain words or numbers: as the time wherein a man tells twice 60, pronouncing every number as faſt as he can conveniently and diſtinctly, is about a Minute; ſo that the time wherein a Man is numbring 60, is a half Minute or 30 ſeconds; and whilſt a Man is numbring two (as one and twenty, two and twenty) is a ſecond; and ſo whilſt a man is numbring from twenty to thirty, is five ſeconds, from twenty to forty, ten ſeconds, *&c.* but in numbring from one and twenty, you may obſerve the ſame times as in numbring from one and twenty to forty, and this will not be hard to do; for whilſt a man pronounceth one and twenty, two and twenty, three and twenty, *&c.* there remains a certain Impreſſion in the Fantaſie, whereby a man is able in the ſame times to pronounce one, two, three, *&c.* And although this rule of numbring twice 60 for a Minutes ſpace be not general unto all men, becauſe ſome are ſwifter or ſlower in their pronunciation than others; yet after this Example, a man making tryal, may frame a Rule to himſelf, whereby he may come ſomething near the truth.

But leaving theſe, we come to the diviſion of the *Log-line*, according to the half Minute-glaſs, which is more uſual and certain. And conſidering that half a Minute is of an hour the $\frac{1}{120}$ part, therefore the Ships way running 51 Feet in half a Minute, is a Mile an hour; if ſhe run twice ſo much, that is, 102 Feet in half a Minute, it is two Miles an hour; if thrice ſo much, it is three Miles an hour; and in general, how many times 51 Feet ſhe runs in half a Minute, ſo many Miles is her way for an hour. Therefore leaving half a ſcore Fathom, or more from the *Log*, that ſo it may be out of the *Eddy* of the Ships wake, before you begin to account or turn the Glaſs; if there you make a Mark for the beginning, and ſo 51 Feet from thence a Mark of one Knot, and 51 Feet farther a Mark of two Knots, and 51 Feet further (that is, 153 Feet from your firſt Mark) another

Mark.

Mark of three Knots, and ſo proceeding: look how many Knots are veered out in half a Minute, ſo many Miles is the Ships way for an hour. Now for that which is veered out more above the juſt meaſure of a Knot or Knots, you may allow for every five Feet the tenth part of a Mile almoſt. As admit ſhe run 5 Knots, and 25 Feet in half a Minute, then is her way according to $5\ \frac{5}{10}$, or five Miles and an half in an hour, if ſix Knots and ten Feet, it is $6\ \frac{2}{10}$ miles in an hour, *&c.*

But according to the common Opinion of 5000 Feet to a Mile, and 60 ſuch miles to a *degree*, there ſhould be ſomething leſs than 7 Fathom, namely, $41\frac{2}{3}$ Feet to a Knot.

And although he which veers the *Log-line* be careful to overhale it ſo ſlack, that it may not draw forwards the *Log*, yet (no doubt) it doth loſe ſome way, following the Ship a little as it is drawn by the Line, and withal by the *Eddy* of the Ships wake, and ſometimes alſo is caſt forwards by the Wind and Waves, when they come after the Ship; ſo that for theſe cauſes, it is like, there may ſometimes be allowed three or four Fathoms more then is veered out; but this (as a thing mutable and uncertain) being ſometimes more, ſometimes leſs, cannot be brought to any certain Rule, but ſuch allowance may be made for it as a man in his experience and diſcretion finds fit.

If you would divide the *Log-line* ſo as it might give the Ships way in *Centeſmes*, or the hundredth part of a *degree*, and fit it to a half Minute-glaſs. Then ſeeing the hundreth part of a *degree* is 3672 Feet, and the $\frac{1}{120}$ part thereof is $30\frac{3}{5}$ Feet; If you begin at the mark at which you mean to turn the Glaſs, and meaſure from thence 30 feet, and 3 fifth parts of a foot, you may there place 1 Knot; and thence again meaſuring 30 feet, and 3 fifth parts of a foot, there place 2 Knots; and ſo proceeding at the end of every 30 feet and 3 fifths, adding a Knot, the number of Knots which run out in half a Minute, is the number of *Centeſmes* which the Ship runs in an hour. As ſuppoſe there run out ten Knots in half a Minute, then the Ships way is according to ten *Centeſmes* of a *degree* in an hour, that is, the tenth part of a *Degree*, or ſix Miles. And ſo every three Foot above the

juſt

juſt meaſure of Knots, is near the tenth part of a *Centeſme*, or the 1000*th* part of a Degree. As if there run out of the *Log-line* 5 Knots and 12 Feet, then the Ships way for an hour is 5 *Centeſmes*, and four tenth parts of a *Centeſme*: the like is to be underſtood of others.

And after the form of theſe Examples you may divide the *Log-line* for any other quantity of Time, more or leſs than half a minute, or for any other parts of a Degree propoſed.

Thus have we handled the Diviſion of the *Log-line*, according to the meaſure before found of 367200 *Engliſh*-feet in a Degree: But becauſe (as I have before ſhewed) the Ships way is commonly more than by the *Log-line* it appears to be, and every man deſires to have his reckoning ſomething before his Ship, that he fall not with a place unexpected; for theſe, and ſuch other cauſes; and for the rotundity of the number, if any man think it more ſafe and convenient in Sea-reckonings, he may abate one in 51, and ſo aſſign to a Degree only 360000 Feet, and conſequently to a mile 6000 *Engliſh*-feet.

And upon this ground, if in half a minute there run out 50 Feet of the *Log-line*, it is a mile an hour; and ſo if 100 Feet run out in a minute.

For, as 1 minute is in proportion to 60 minutes:

So is 100 Feet to 6000 Feet.

And ſo foraſmuch as twenty five Feet is $\frac{1}{240}$ part of a mile, and 15 *ſeconds* is alſo $\frac{1}{240}$ part of an hour: Therefore if there be two Marks on the Ships ſide diſtant 25 Feet, if the Ship run the diſtance of theſe two Marks in 15 *ſeconds*, it is after the rate of a mile an hour; if in 5 *ſeconds*, it is 3 miles an hour; and ſo always dividing 15 *ſeconds* by the number of *ſeconds* in which the Ship runs that diſtance; the Quotient ſhews the miles and parts of a mile run in an hour. But if the diſtance of theſe two Marks be 50 Foot, then if ſhe run it in 30 *ſeconds*, or half a Minute, it is a mile an hour; if in 10 *ſeconds*, 3 miles an hour; if in five *ſeconds*, ſix miles an hour, (for thirty divided by five, the Quotient is 6.) And ſo always dividing thirty *ſeconds* by the number of *ſeonds*, in which the Ship runs that Diſtance;

ſtance; the Quotient ſhews how many miles ſhe runs in an hour, *&c.*

Otherwiſe, if you make a Mark on the Ships ſide at every twenty Inches, then when the Ship runs one of theſe parts in a *ſecond* of time, it is a mile an hour: when five, it is five miles an hour: if ſhe run 18 of theſe parts in three *ſeconds*, it is ſix miles an hour. For dividing 18 by 3, the Quotient is ſix. And in general, if you divide the number of the parts run, by the number of *ſeconds* ſpent in running, the Quotient ſhews the Ships way in Miles for an hour.

But for dividing the *Log-line* according to this ground of 6000 Feet in a Mile, if you intend to uſe it with a half Minute-glaſs; then becauſe half a Minute is $\frac{1}{120}$ part of an hour, and 50 Feet is alſo the $\frac{1}{120}$ part of a Mile: Therefore when the Ship runs 50 Feet in half a Minute, her way is after the rate of a Mile an hour; if 100 Feet in half a Minute, it is two miles an hour, *&c.*

Therefore half a ſcore Fathoms or more from the *Log*, you may make a Mark, and beginning from thence meaſure 50 Feet, and there make the firſt Knot, and 50 Foot farther two Knots, and 50 Foot farther three Knots, and ſo proceeding: Look how many Knots is run out in half a Minute, ſo many Miles is the Ships way for an hour: and every 5 Feet more beſides the Knots, is a tenth part of a Mile; as if there run out 6 Knots and 20 Feet in half a Minute, the Ships way is after the rate of $6\frac{4}{10}$ Miles in an hour, *&c.*

And ſo if the Glaſs were for any other time more or leſs than half a Minute, you may make the diſtance of your Knots proportional: as if it were for 20 *ſeconds*, then becauſe 20 *ſeconds* is of an hour the $\frac{1}{180}$ part, I divide a Mile, which is 6000 Feet, by 180, and the Quotient is $33\frac{1}{3}$; therefore there muſt be a Knot at every 33 Feet and 4 Inches.

If your Glaſs be 36 *ſeconds*, which is $\frac{1}{100}$ part of an hour, divide 6000 by 100, the quotient is 60, ſhewing that there muſt be 60 Feet to every Knot, and then every 6 Foot over and above the Knots, is a tenth part of a Mile more.

And

And ſo it is better that your Glaſs be more than half a Minute rather than leſs; and the more the better, provided that there run out no more Line then you may hall in again, without danger of breaking.

Laſtly, if you would ſo divide the *Log-line*, that it might ſhew the Ships way in *Centeſmes* of a *degree*, and fit it to an half Minute-glaſs: Then foraſmuch as the hundreth part of a *degree* is 3600 feet, and the $\frac{1}{120}$ part thereof is 30 feet; therefore beginning at the mark whereat you intend to turn the Glaſs, meaſure from thence 30 feet, and there make one Knot, and at 30 feet farther two Knots, *&c.* Then look how many Knots run out in half a minute, ſo many *Centeſmes* of a *degree* is the Ships way for an hour. And ſo if the Glaſs be 36 ſeconds, then every Knot muſt have 36 Feet.

Now if a man Sailing between any two places which lie near Eaſt and Weſt one from another, have kept his Reckoning by Courſe and Diſtance, uſing a *Log-line* ſo divided, that it have a Knot at every 7 Fathoms (as many do) and would reduce the Diſtance of thoſe two places ſo found, to their Diſtance in ſuch miles, as theſe of ſixty to a *Degree*, each containing (as we have ſaid) 6000 feet: The proportion in number of thoſe to theſe, is as 6 to 5, for 6 of them make 5 of theſe.

As admit a man in his dead Reckoning, uſing ſuch a *Log-line*, as hath a Knot at every 7 Fathoms, and for every Knot running out in half a minute, he accounts the Ships way to be ſo many miles an hour; and according to ſuch a Reckoning, ſuppoſe he find the diſtance of two places to 1224 miles, or 408 Leagues, and would know the Diſtance of the ſame places in miles of 6000 feet to a mile, which is according to a *Log-line* that hath a Knot in every 50 feet.

Say then by the Rule of Proportion;

As the number 6	*Co. ar.*	9.22185
Is in proportion to 5.		0.69897
So is the number of miles given 1224		3.08778
To the number of miles required, 1020		3.00860

Which

Which 1020 is the Diſtance of thoſe two places, in ſuch miles whereof 60 make a *degr.* Or to find the ſame in Leagues, the Proportion is; As 6 to 5; ſo is 408 Leagues, to 340 Leagues.

And thus may the diſtance of Places be found in ſuch miles, whereof 60 make a *degr.* eſpecially if with the diſtance expreſſed in the *plain Chart*, you compare the reckonings of ſome skilful Mariners that have Sailed from the one to the other. But thus to endeavour a Reformation of the *plain Chart*, were a labour to little purpoſe; For there the correcting of the true ſituation of two places, in reſpect of one another, is oftentimes an occaſion that the ſame places are the moſt falſly ſituare in reſpect of others. Like as if there were two places 8 miles diſtant, and it were required to place a third three miles from either of them; Here if we ſet the third in the middle, it will be four miles diſtant from either: But if (attempting to mend that Errour) we make the third to be 3 miles from the firſt, then will it be 5 miles from the ſecond: And thus unavoidably, the mending of the one, is the marring of the other; becauſe the thing propoſed is not poſſible.

And ſuch is the Errour of the Plain or common *Sea-Chart*, repreſenting the Earth and Sea, not as a Spherical, but as a Plain *Superficies*; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the graduation and projection being ſuch, the Situations and Diſtances of places, cannot be generally and truly expreſſed therein.

But the graduation and Projection of *Mercators Chart*, agreeing without ſenſible errour with the *Globe*, there may in that be deſcribed all or any parts of the World, according to their Longitudes, Latitudes, Courſes, and Diſtances, as truly, and far more conveniently for the *Mariners* uſe then upon the *Globe* it-ſelf; and upon ſuch a *Chart* ſo deſcribed, a reckoning may be truly kept, and any Erronr committed, may eaſily be diſcerned and amended. Whereas on the *plain Chart*, if a man find his reckoning to diſagree, he is ſo far from knowing how to amend it, that he can ſeldom conjecture where the fault was.

The neglect and want of theſe *Charts* hath been, and is a great imperfection in *Navigation* and *Geography*. For howſoever there be ſome which do daily ſet forth for ſale Maps of the world, and of the parts thereof, according to this Projection: Yet to have them truly ſuch, and fit for *Navigation*, requires in the Author or maker of them good knowledge, and ſome competent ability of his own, or aid from others, with a greater love to the Truth, than to his own Profit, which may induce him to beſtow ſuch Induſtry, Time, and Expence, as I have formerly noted to be reſited in ſuch a Work.

For the furtherance whereof, and of the Practice of *Navigation* in general, I ſhall endeavour in the two next Chapters to ſhew a methodical and orderly way of keeping a reckoning at Sea, more diſtinctly and exactly than hath been formerly uſed, and ſuch as may aptly be ſet down in any *Chart*, and applyed in the three principal kinds of Sailing; namely, according to the *Plain Chart*, or *Mercator's*, or according to the Arch of a great *Circle*. And by a few reckonings truly ſet down, according to this form, the Maps of the World, and of the parts thereof, might be much reformed.

CHAP. VIII.

A formal and exact way of ſetting down and perfecting a Sea-reckoning.

ALthough the Courſe and Diſtance cannot be ſo truly and certainly known as the Latitude may be: yet we muſt endeavour in theſe alſo to come as near the Truth as may be, the rather for that ſome reckonings muſt neceſſarily depend wholly upon them. And to that end, thoſe which in their Voyages at Sea have occaſion to run far upon any Courſe or Courſes near the Meridian, may do well to make tryal of that which I have formerly ſet down, touching the quantity

tity of a *degr.* on the Earth and Sea in our known Meaſure; and eſpecially in the *Eaſt-India* Voyages; Sailing from the *Lizard* in the Weſt part of *England*, to *Cape de bonne Eſperance* in *Africk*, they have opportunity of making an ample Experiment hereof.

But leaving this to the Practice of the skilful and induſtrious *Sea-man*, we come now to ſhew an orderly and exact way of framing and keeping a reckoning at Sea: for which purpoſe I have made the *Table* following, which ſheweth how much a Ship is more Northerly or Southerly, and how much more Eaſterly or Weſterly, by Sailing upon any Point or half Point of the *Compaſs*, any number of Miles propoſed.

The like *Table* I made many Years ſince, and taught the Uſe of it in *Navigation*; whether it were then uſed by any other, I know not, I had it of no Man; but this I ſpeak, that if any Man claim the firſt Making and Uſe of ſuch an one, he may have it.

The Ground of making this *Table* is the ſame with the former. *For as* Radius *is in proportion to the Diſtance run, So is the Sine Complement of the* Rumb, *to the Diſtance of North or South, and ſo is the Sine of the* Rumb, *to the Diſtance of Eaſt or Weſt.* Therefore here for 10 Miles upon any of the four Points from the Meridian, we ſet in the ſecond Column the Sine Complement of that Point (reduced into *degr.*) and in the third the Sine thereof. As the ſecond Rumb or Point from the Meridian, being 22 *degr.* 30 *min.* the Sine Complement thereof which is 9239 ſet in the ſecond Column againſt 10: and the Sine thereof 3827, I ſet there in the third Column; and having done thus for 10 Miles in every Column, the reſt may be eaſily drawn from them.

As in the ſecond Column, for the firſt half Point againſt 10 Miles findinding 9952, I ſet the half thereof; namely 4976 againſt 5 Miles, and the tenth part thereof, namely, 995 againſt one Mile, which doubled or added to it ſelf, is 1990, to be ſet againſt two Miles, whereto adding the ſame 995, the Sum is 2985 for three Miles; and ſo for the reſt.

And thus for every Point and half Point from the Meridian, there are three Columns: In the firſt whereof there is ſet down a number of Miles run upon that Point or half Point; the ſecond ſheweth how much the Latitude is altered; that is, how much you are more Southerly or Northerly, by running ſo far upon that Point or half Point; the third, how much you are more Eaſterly or Weſterly, by running that Courſe and Diſtance.

The numbers ſet in every firſt Column from 1 to 10, are alſo to be underſtood from 10 to 100, or from 100 to 1000, and the Figure in the fourth place of the ſecond and third Columns, anſwer to the Figure in the firſt. As admit a Ship run South and by Weſt (that is (South 1 Point Weſterly) 165 Miles,) I ſet down this number thus; and looking in the Columns of the firſt *Rumb* againſt 10 (which may be underſtood to be 100) I find againſt it in the ſecond Column 981 almoſt, and in the third 195, alſo againſt 60 (that is 6) in the firſt Column, there is 588 in the ſecond, and 117 in the third: alſo againſt 5 in the firſt Column, there is 49 in the ſecond, and almoſt 10 in the third.

	100	981	195
S. W. 1	60	588	117
point.	5	49	10
	165	161.8	32.2

Theſe ſet down, and ſumm'd up as here appeareth, ſhew that a Ship running *S* by *W* 165 Miles, is to the Southwards of the place from whence ſhe departed 161 Miles, and 8 Tenth parts of a mile, and to the Weſtwards 32 miles, and 2 Tenth parts of a mile. If you deſire more exactneſs, you may uſe all the places for the firſt or greateſt number, which is here 100.

	100	9808	1950
S. W. 1.	60	5885	1170
point.	5	490	97
	165.	161.83	32.17

As in the ſecond Example, where the Southerly Diſtance is 161 $\frac{83}{100}$ miles, and the Weſterly 32 $\frac{17}{100}$ miles.

A Table

A Table of the Northing or Southing, Easting or Westing of every Rumb and half Rumb from the Meridian; according to the number of Miles run upon that Rumb.

	½ poin.	7½ poin.	1 poin.	7 poin.	1½ poin.	6½ poin.	2 point.	6 point.
M	5.37½	84.22½	11.15	78.45	16.52	73.7½	22.30	67.30
1	995	98	981	195	957	290	924	303
2	1990	106	1962	390	1914	580	1848	766
3	2986	294	2943	585	2871	870	2772	1148
4	3981	392	3923	780	3827	1161	3696	1531
5	4976	490	4904	975	4784	1451	4620	1914
6	5971	588	5885	1170	5741	1741	5544	2297
7	6966	686	6866	1365	6698	2031	6468	2680
8	7961	784	7846	1560	7655	2321	7392	3062
9	8957	882	8827	1755	8612	2612	8315	3445
10	9952	980	9808	1950	9569	2902	9239	3827

	2½ poin.	5½ poin.	3 point.	5 point.	3½ poin.	4½ poin.	4 point.	4 point.
M	28.7½	61.52½	32.45	59.15	39.22½	50.37½	45.00	45.00
1	882	471	831	556	773	634	707	707
2	1764	942	1663	1111	1546	1269	1414	1414
3	2646	1414	2494	1667	2319	1903	2121	2121
4	3528	1885	3326	2222	3092	2538	2828	2828
5	4410	2357	4158	2778	3865	3172	3535	3535
6	5292	2828	4989	3334	4638	3806	4242	4242
7	6174	3300	5820	3890	5411	4440	4949	4949
8	7056	3771	6652	4445	6185	5075	5656	5656
9	7937	4243	7483	5000	6957	5710	6364	6364
10	8819	4714	8315	5556	7730	6344	7071	7071

A larger Example may be that before set down in the last *Problem* of Sailing by a *Great Circle* from *Summers-Islands* to the *Lizard*, pag. 127.

As

As admit I Sail from thence; First, *N E* ½ Point Easterly 600 Miles, then *N E* by *E* 300 Miles; East Northeast half a Point Northerly 465 Miles; *E N E* 390 Miles; *E N E* ½ Point Easterly 294 Miles; *E* by *N* 210 Miles; East 951 Miles: These Courses and Distances I set down in such form as here appeareth, where in the first Column there is expressed the Course or Point of the Compass upon which a Man Sails: In the second Column, the Distance of that Rumb from the Meridian: In the third Column, the Distance run upon that Point; In the rest, the difference of Latitude, and departure from the Meridian in Miles, and tenth parts of a Mile.

Course.	*Rumb from me.*	*Dist. miles.*	*North.*	*South.*	*East.*	*West.*
N E ½ *Po. E.*	*North Easterly.* 4 ½ P.	600	380.6		463.8	
N E by *E.*	*N East.* 5 Point.	300	166.7		2494	
E N E ½ *Po. N.*	*N East* 5 ½ Po.	400 90 5	1885 424 24		35228 794 44	
E N E	*N East* 6 Point.	300 90	1148 344		277.2 831	
E N E ½ *Po. E.*	*N East* 6 ½ Point	200 60 4	580 174 12		1914 574 38	
E by *N*	*N East* 7 Point.	200 10	390 20		1962 98	
East.	*East.*	900 50 1			9510	
		3210	1047.4		29197	

(In

(In all which is to be conceived, that the *Variation* are allowed) ſo that at the Foot of this reckoning, I find the Sum of the North Column to be 1047 $\frac{4}{10}$ Miles, and the Sum of the Eaſt Column 2920 Miles almoſt; the firſt, namely, 1047 miles converted into *degr.* is, 7 *degr.* 27 *min.* the difference of Latitude, which added to the Latitude of *Summers-Iſlands* 32 *deg.* 25 *min.* (where this reckoning began) the Sum is 49 *deg.* 52 *min.* which is the Latitude of this laſt place where this reckoning endeth. So that according to this account, the Ship is run into the Latitude of 49 *deg.* 52 *min.* and hath altered her Longitude to the Eaſtwards 2920 miles, of ſuch miles, whereof 60 make a *degr.* of a great Circle,

Therefore, if you ſet down this reckoning on the *Plain Chart*, you muſt make a Point in the *Chart* that may be in the Latiutde of 49 *deg.* 52 *min.* and to the Eaſtwards of *Summers-Iſlands*, (where this reckoning began) 2920 miles, that is, you muſt run a parallel (with your Compaſſes or otherwiſe) on your *Chart* in the Latit. of 49 *deg.* 52 *min.* and croſs the ſame by a Meridian, which may be to the Eaſtwards of the Merid. of *Summers-Iſlands* 2920 miles, and ſo the Point of the Interſection of this Parallel and Meridian, is the Traverſe-point or Point in the *Chart* repreſenting the place where the Ship is in the end of this reckoning.

But if you ſet down this reckoning on *Mercators Chart*, you muſt alſo find a Point that may be in the Latitude of 29 *degr.* 52 *min.* and may likewiſe be to the Eaſtwards of *Summers-Iſlands* 2920 miles, which is done by running with your Compaſſes a Parallel in the Latitude of 49 *degr.* 52 *min.* and croſſing the ſame by a Meridian, which may be to the Eaſtwards of the Meridian of *Summers-Iſlands* 2920 miles, the Point of the Interſection of this Parallel with that Meridian, is the Traverſe-point, repreſenting in the *Chart* the place where the Ship then is.

For it is to be conceived in this *Chart*, that the *degrees* of the Meridian intercepted between the Latitudes of two places are as a Scale for thoſe two places, to meaſure not only their difference of Latitude, but likewiſe their Diſtance in their Rumb, as alſo the Diſtance of their Meridians.

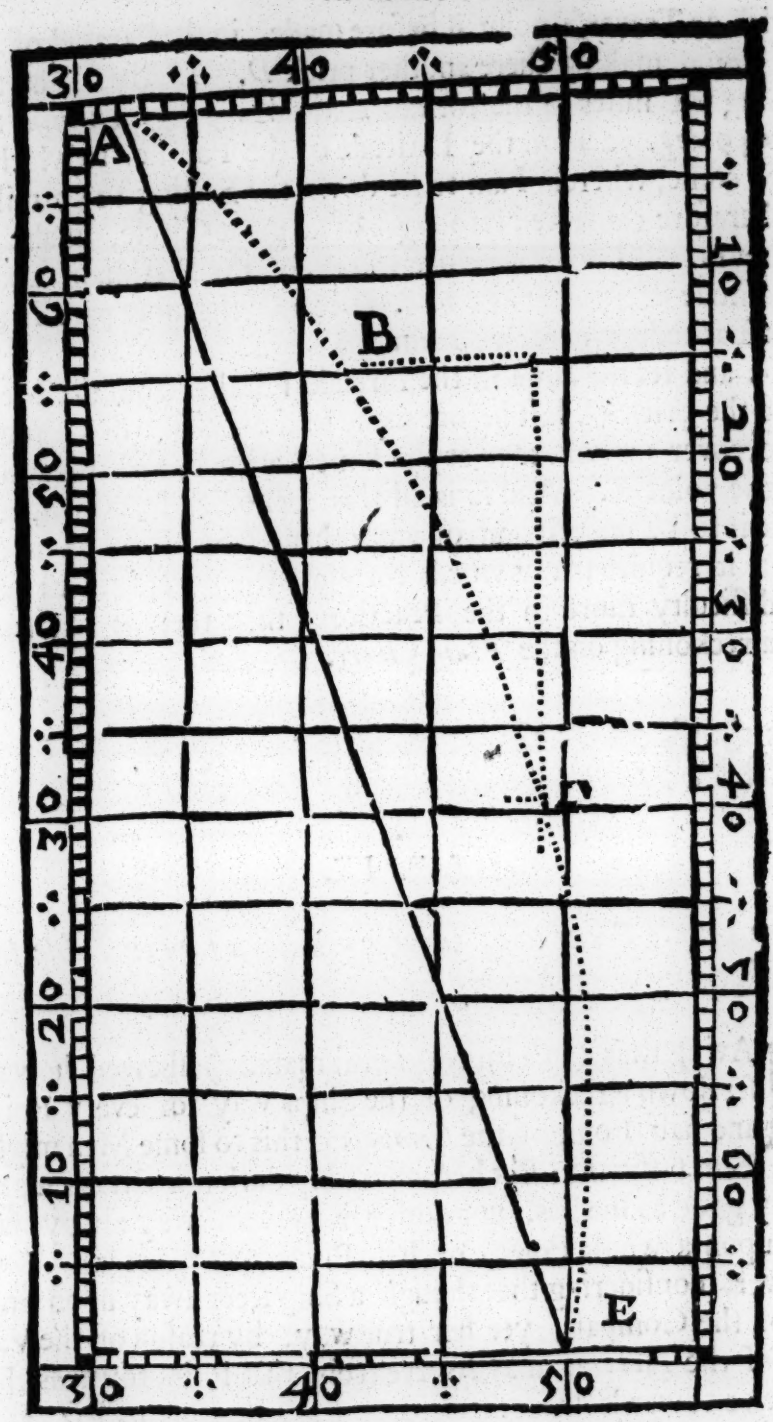
But

But becauſe it often falls out, that in Sailing from place to place, a Ship runs not near the Rumb of the two places by many hundred miles, eſpecially in ſailing by the Arch of a *great Circle*, which is the moſt exquiſite manner of Sailing, and wherein a man ſhifts his Courſe often, and runs much farther in one Latitude than in another, as by the former Example may appear. Therefore once in three or four days, or ſo often as you alter your Courſe much, you may tranſfer or ſet down your Reckoning out of your Book into your *Chart*. As in transferring the former Example, you may ſet down the Northing and Eaſting of every of the Courſes ſeverally; but for brevity ſake we will bring them into three parts (and ſo alſo we ſhall not much err.)

And thus for the two firſt Courſes, namely *N E* ½ Point Eaſterly 600 miles, and *N E* by *E* 300 miles, I find in the North Column 547 Miles; and in the Eaſt Column 713 miles: alſo for the three next Courſes, ſumming up the North and Eaſt Columns, I find the Northing to be 459 miles; and the Eaſting 1050 miles. Alſo for the two laſt Courſes, I find the Northing to be 41 miles, and the Eaſting 1157 miles.

North.	*Eaſt.*
547	713
459	1050
41	1157
1047	2920

Now to tranſfer theſe into the *Chart*, I conſider that 547 miles is 9 *degr.* 7 *min.* which added to the former Latitude 32 *degr.* 25 *min.* makes Latitude 41 *degr.* 32 *min.* In which Latitude I run a Parallel, then conſidering that 713 miles is 11 *degr.* 53 *min.* I take this 11 *degr.* 53 *min.* in the Meridian, as much above the one Latitude, as beneath the other, namely, from 31 *degr.* 0 *min.* to 42 *degr.* 53 *min.* and this I ſet in the foreſaid Parallel from the Meridian of *Summers-Iſlands* to the Eaſtwards, and there make the Point *B*, then reducing 459 miles into *degr.* it makes 7 *deg.* 39 *min.* which added to 41 *deg.* 32 *min.* makes Latitude 49 *deg* 11 *min.* Alſo the Eaſting 1050 miles are 17 *deg.* 30 *min.* the half whereof 8 *deg.* 45 *min.* I take in the Meridian from above 41 *degr.* 32 *min.* beneath 49 *degr.* 11 *min.* namely, from 41 *deg.* 20 *min.* to 50 *deg.* 5 *min.* And this being doubled (becauſe it is but the half) I ſet from the Meridian of the


A
B
E
30
40
50
60
10
20
30
40
50
60
10
20
30
40
50

the Prick or Traverſe-point *B* before made, in the Parallel of 49 *deg.* 11 *min.* making there another prick *D.* Laſtly, I add the Northing 41 miles to the former Latitude 49 *deg.* 11 *min.* the Sum is 49 *deg.* 52 *min.* the Latitude of the Parallel to which I am now come, wherein I am to ſet down the Eaſting 1157 miles. This therefore converted into *degr.* of a great Circle, make 19 *degr.* 17 *min.* I take therefore 1 *degr.* of the Meridian, about that Latitude of 49 *degr.* 52 *min.* (becauſe the moſt part is run in that Latitude,) namely, from 49 *degr.* 30 *min.* to 50 *degr.* 30 *min.* and ſet the ſame in the foreſaid Parallel from the Meridian of the prick *D.* laſt before made to the Eaſtwards 19 times, and moreover 17 *min.* take at the ſame Latitude, and this reacheth to the point *E.* And ſo is all this reckoning ſet down, and the like is to be underſtood of any other, which though in expreſſion it require many words for plainneſs; yet is there very little difficulty more in the Practice, than there is in ſetting down a reckoning on the *Plain Chart.*

CHAP. IX.

A more ample Example, together with a larger Table for the keeping a reckoning at Sea.

HAving thus (in a more general manner) ſhewed how to ſet down a reckoning of the Ships way for every Point and half Point of the *Compaſs*; this to ſome Men might ſeem ſufficient: But becauſe a Ship doth not always make her way good as ſhe lies, nor doth her *Leeward*-way always fall juſtly upon a whole Point, or half-Point, or quarter; And moreover, conſidering that though a Ship ſteer away upon any Point of the Compaſs, yet her true way, by reaſon of the Variation of the *Needle*, may ſwerve from that Point towards the one ſide or towards the other 3 or 4 *degr.* or more or leſs, and not

not always a Point, or half a Point, or quarter: therefore I have thought it requiſite to ſet down the Table following to every ſingle *deg.* and that a man might the more readily with one or two Entrances have his deſire; I have alſo enlarged the number of miles unto 100. The Ground and way of making this Table differs not from the former, and it is to be uſed almoſt in the ſelf ſame manner: wherefore we ſhall uſe the more brevity in handling of it.

Here followeth a Table of the Northing or Southing, Eaſting or Weſting of every *degr.* from the Meridian, according to the number of Miles run upon that *degr. which for brevity ſake we call* ——

A

TABLE

FOR THE

DIFFERENCE

OF

LATITUDE,

AND

Departure from the *Meridian.*

M.	1 d.	89 d.
1	10	0
2	20	0
3	30	0
4	40	1
5	50	1
6	60	1
7	70	1
8	80	1
9	90	2
10	100	2
11	110	2
12	120	2
13	130	2
14	140	2
15	150	3
16	160	3
17	170	3
18	180	3
19	190	3
20	200	4
21	210	4
22	220	4
23	230	4
24	240	4
25	250	4
26	260	5
27	270	5
28	280	5
29	290	5
30	300	5
31	310	5
32	320	6
33	330	6
34	340	6

M.	1 d.	89 d.
35	350	6
36	360	7
37	370	7
38	380	7
39	390	7
40	400	7
41	410	7
42	420	7
43	430	8
44	440	8
45	450	8
46	460	8
47	470	8
48	480	9
49	490	9
50	500	9
51	510	9
52	520	9
53	530	9
54	540	10
55	550	10
56	560	10
57	570	10
58	580	10
59	590	10
60	600	11
61	610	11
62	620	11
63	630	11
64	640	11
65	650	12
66	660	12
67	670	12
68	680	12

Min.	1 d.	89 d.
69	690	12
70	700	12
71	710	13
72	720	13
73	730	13
74	740	13
75	750	13
76	760	13
77	770	14
78	780	14
79	790	14
80	800	14
81	810	14
82	820	14
83	830	15
84	840	15
85	850	15
86	860	15
87	870	15
88	880	15
89	890	16
90	900	16
91	910	16
92	920	16
93	930	16
94	940	17
95	950	17
96	960	17
97	970	17
98	980	17
99	990	17
100	1000	18
200	2000	35
300	3000	53

M.	2 d.	88 d.
1	10	0
2	20	1
3	30	1
4	40	1
5	50	2
6	60	2
7	70	2
8	80	3
9	90	3
10	100	3
11	110	4
12	120	4
13	130	4
14	140	5
15	150	5
16	160	6
17	170	6
18	180	6
19	190	7
20	200	7
21	210	7
22	220	8
23	230	8
24	240	8
25	250	9
26	260	9
27	270	9
28	280	10
29	290	10
30	300	10
31	310	11
32	320	11
33	330	11
34	340	12

M.	2 d.	88 d.
35	350	12
36	360	13
37	370	13
38	380	13
39	390	14
40	400	14
41	410	14
42	420	15
43	430	15
44	440	15
45	450	16
46	460	16
47	470	16
48	480	17
49	490	17
50	500	17
51	510	18
52	520	18
53	530	18
54	540	19
55	550	19
56	560	19
57	570	20
58	580	20
59	590	20
60	600	21
61	610	21
62	620	22
63	630	22
64	640	22
65	650	23
66	660	23
67	670	23
68	680	24

Min.	2 d.	88 d.
69	690	24
70	700	24
71	710	25
72	720	25
73	730	25
74	740	26
75	750	26
76	760	26
77	770	27
78	780	27
79	790	28
80	800	28
81	809	28
82	819	29
83	829	29
84	839	29
85	849	30
86	859	30
87	869	30
88	879	31
89	889	31
90	899	31
91	909	32
92	919	32
93	929	32
94	939	33
95	949	33
96	959	34
97	969	34
98	979	34
99	989	35
100	999	35
200	1999	70
300	2998	105

M.	3 d.	87 d.
1	10	1
2	20	1
3	30	1
4	40	2
5	50	2
6	60	3
7	70	4
8	80	4
9	90	5
10	100	5
11	110	6
12	120	6
13	130	7
14	140	7
15	150	8
16	160	8
17	170	9
18	180	9
19	190	10
20	200	10
21	210	11
22	220	11
23	230	12
24	240	12
25	250	13
26	260	13
27	270	14
28	280	15
29	290	15
30	300	16
31	310	16
32	320	17
33	330	17
34	340	18
35	350	18
36	360	19
37	370	19
38	380	20
39	390	20
40	400	21
41	410	21
42	420	22
43	430	22
44	440	23
45	450	23
46	460	24
47	470	24
48	480	25
49	490	26
50	500	26
51	509	27
52	519	27
53	529	28
54	539	28
55	549	29
56	559	29
57	569	30
58	579	30
59	589	31
60	599	31
61	609	32
62	619	32
63	629	33
64	639	33
65	649	34
66	659	35
67	669	35
68	679	36

Min.	3 d.	87 d.
69	689	36
70	699	37
71	709	37
72	719	38
73	729	38
74	739	39
75	749	39
76	759	40
77	769	40
78	779	41
79	789	41
80	799	42
81	809	42
82	819	43
83	829	43
84	839	44
85	849	44
86	859	45
87	869	45
88	879	46
89	889	46
90	899	47
91	909	48
92	919	48
93	929	49
94	939	49
95	949	50
96	959	50
97	869	51
98	979	51
99	989	52
100	999	52
200	1997	105
300	2996	157

M.	4 d.	86 d.
1	10	1
2	20	1
3	30	2
4	40	3
5	50	3
6	60	4
7	70	5
8	80	6
9	90	6
10	100	7
11	110	8
12	120	8
13	130	9
14	140	10
15	150	10
16	160	11
17	170	12
18	180	13
19	190	13
20	200	14
21	209	15
22	219	15
23	229	16
24	239	17
25	249	17
26	259	18
27	269	19
28	279	20
29	289	20
30	299	21
31	309	22
32	319	22
33	329	23
34	339	24

M.	4 d.	86 d.
35	349	25
36	359	25
37	369	26
38	379	27
39	389	27
40	399	28
41	409	29
42	419	29
43	429	30
44	439	31
45	449	31
46	459	32
47	369	33
48	479	34
49	489	34
50	499	35
51	509	36
52	519	36
53	529	37
54	539	38
55	549	38
56	559	39
57	569	40
58	579	40
59	589	41
60	599	42
61	609	43
62	619	43
63	629	44
64	639	45
65	648	45
66	658	46
67	668	47
68	678	48

Min.	4 d.	86 d.
69	688	48
70	698	49
71	708	50
72	718	50
73	728	51
74	738	52
75	748	52
76	758	53
77	768	54
78	778	55
79	788	55
80	798	56
81	808	57
82	818	57
83	828	58
84	838	59
85	848	59
86	858	60
87	868	61
88	878	61
89	888	62
90	898	63
91	908	63
92	918	64
93	928	65
94	938	66
95	948	66
96	958	67
97	968	68
98	978	68
99	988	09
100	998	70
200	1995	140
300	2993	209

M.	5 d.	85 d.	M.	5 d.	85 d.	Min.	5 d.	85 d.
1	10	1	35	349	30	69	687	60
2	20	2	36	359	31	70	697	61
3	30	3	37	369	32	71	707	62
4	40	3	38	379	33	72	717	63
5	50	4	39	388	34	73	727	64
6	60	5	40	398	35	74	737	65
7	70	6	41	408	36	75	747	65
8	80	7	42	418	37	76	757	66
9	90	8	43	428	37	77	767	67
10	100	9	44	438	38	78	777	68
11	110	10	45	448	39	79	787	69
12	120	10	46	458	40	80	797	70
13	130	11	47	468	41	81	807	71
14	140	12	48	478	42	82	817	71
15	150	13	49	488	43	83	827	72
16	160	14	40	598	44	84	837	73
17	170	15	51	508	45	85	847	74
18	180	16	52	518	45	86	857	75
19	190	17	53	528	46	87	867	76
20	200	17	54	538	47	88	877	77
21	209	18	55	548	48	89	887	78
22	219	19	56	558	49	90	897	78
23	229	20	57	568	50	91	907	79
24	239	21	58	578	51	92	916	80
25	249	22	59	588	52	93	926	81
26	259	22	60	598	52	94	936	82
27	269	24	61	608	53	95	946	83
28	279	24	62	618	54	96	956	84
29	289	25	63	628	55	97	966	84
30	299	26	64	638	56	98	976	85
31	309	27	65	648	57	99	986	86
32	319	28	66	658	58	100	996	87
33	329	29	67	668	58	200	1992	174
34	330	30	68	677	59	300	2989	262

M.	6 d.	84 d.
1	10	1
2	20	2
3	30	3
4	40	4
5	50	5
6	60	6
7	70	7
8	80	8
9	89	9
10	99	10
11	109	11
12	119	12
13	129	14
14	139	15
15	149	16
16	159	17
17	169	18
18	179	19
19	189	20
20	199	21
21	209	22
22	219	23
23	229	24
24	239	25
25	249	26
26	259	27
27	269	28
28	278	29
29	288	30
30	298	31
31	308	32
32	318	33
33	328	34
34	338	75

M.	6 d.	84 d.
35	348	36
36	358	38
37	368	39
38	378	40
39	388	41
40	398	42
41	408	43
42	418	44
43	428	45
44	438	46
45	447	47
46	457	48
47	467	49
48	477	50
49	487	51
50	497	52
51	507	53
52	517	54
53	527	55
54	537	56
55	547	57
56	557	58
57	567	59
58	577	61
59	587	62
60	697	63
61	607	64
62	617	65
63	627	66
64	637	67
65	646	68
66	656	69
67	666	70
68	676	71

Min.	6 d.	84 d.
69	686	72
70	696	73
71	706	74
72	716	75
73	726	76
74	736	77
75	746	78
76	756	79
77	766	80
78	776	81
79	786	82
80	796	83
81	806	85
82	815	86
83	825	87
84	835	88
85	845	89
86	855	90
87	865	91
88	875	92
89	885	93
90	895	94
91	905	95
92	915	96
93	925	97
94	935	98
95	945	99
96	955	100
97	965	101
98	975	102
99	985	103
100	995	104
200	1980	209
300	2983	313

M.	5 d.	85 d.
1	10	1
2	20	2
3	30	3
4	40	3
5	50	4
6	60	5
7	70	6
8	80	7
9	90	8
10	100	9
11	110	10
12	120	10
13	130	11
14	140	12
15	150	13
16	160	14
17	170	15
18	180	16
19	190	17
20	200	17
21	209	18
22	219	19
23	229	20
24	239	21
25	249	22
26	259	22
27	269	24
28	279	24
29	289	25
30	299	26
31	309	27
32	319	28
33	329	29
34	330	30

M.	5 d.	85 d.
35	349	30
36	359	31
37	369	32
38	379	33
39	388	34
40	498	35
41	408	36
42	418	37
43	428	37
44	438	38
45	448	39
46	458	40
47	468	41
48	478	42
49	488	43
40	598	44
51	508	45
52	518	45
53	528	46
54	538	47
55	548	48
56	558	49
57	568	50
58	578	51
59	588	52
60	598	52
61	608	53
62	618	54
63	628	55
64	638	56
65	648	57
66	658	58
67	668	58
68	677	59

Min.	5 d.	85 d.
69	687	60
70	697	61
71	707	62
72	717	63
73	727	64
74	737	65
75	747	65
76	757	66
77	767	67
78	777	68
79	787	69
80	797	70
81	807	71
82	817	71
83	827	72
84	837	73
85	847	74
86	857	75
87	867	76
88	877	77
89	887	78
90	897	78
91	907	79
92	916	80
93	926	81
94	936	82
95	946	83
96	956	84
97	966	84
98	976	85
99	986	86
100	996	87
200	1992	174
300	2989	262

M.	6 d.	84 d.	M.	6 d.	84 d.	Min.	6 d.	84 d.
1	10	1	35	348	36	69	686	72
2	20	2	36	358	38	70	696	73
3	30	3	37	368	39	71	706	74
4	40	4	38	378	40	72	716	75
5	50	5	39	388	41	73	726	76
6	60	6	40	398	42	74	736	77
7	70	7	41	408	43	75	746	78
8	80	8	42	418	44	76	756	79
9	89	9	43	428	45	77	766	80
10	99	10	44	438	46	78	776	81
11	109	11	45	447	47	79	786	82
12	119	12	46	457	48	80	796	83
13	129	14	47	467	49	81	806	85
14	139	15	48	477	50	82	815	86
15	149	16	49	487	51	83	825	87
16	159	17	50	497	52	84	835	88
17	169	18	51	507	53	85	845	89
18	179	19	52	517	54	86	855	90
19	189	20	53	527	55	87	865	91
20	199	21	54	537	56	88	875	92
21	209	22	55	547	57	89	885	93
22	219	23	56	557	58	90	895	94
23	229	24	57	567	59	91	905	95
24	239	25	58	577	61	92	915	96
25	249	26	59	587	62	93	925	97
26	259	27	60	697	63	94	935	98
27	269	28	61	607	64	95	94-	99
28	278	29	62	617	65	96	955	100
29	288	30	63	627	66	97	965	101
30	298	31	64	637	67	98	975	102
31	308	32	65	646	68	99	985	103
32	318	33	66	656	69	100	995	104
33	328	34	67	666	70	200	1980	209
34	338	75	68	676	71	300	2983	313

M.	7 d.	83 d.	M.	7 d.	83 d.	Min.	7 d.	83 d.
1	10	1	35	347	43	69	685	84
2	20	2	36	357	44	70	695	85
3	30	4	37	367	45	71	705	87
4	40	5	38	377	46	72	715	88
5	50	6	39	387	48	73	725	89
6	60	7	40	397	49	74	734	90
7	69	8	41	407	50	75	744	92
8	79	10	42	417	51	76	754	93
9	89	11	43	427	52	77	764	94
10	99	12	44	437	54	78	774	95
11	109	13	45	447	55	79	784	96
12	119	15	46	456	56	80	794	98
13	129	16	47	466	57	81	804	99
14	139	17	48	476	59	82	814	100
15	149	18	49	486	60	83	824	101
16	159	20	50	596	61	84	834	103
17	169	21	51	506	62	85	844	104
18	179	22	52	516	63	86	854	105
19	189	23	53	526	65	87	863	106
20	199	24	54	536	66	88	873	107
21	208	26	55	546	67	89	883	109
22	218	27	56	556	68	90	893	110
23	228	28	57	566	69	91	903	111
24	238	29	58	576	71	92	913	112
25	248	30	59	586	72	93	923	113
26	258	32	60	696	73	94	933	115
27	268	33	61	605	74	95	943	116
28	278	34	62	615	76	96	953	117
29	288	55	63	625	77	97	963	118
30	298	37	64	635	78	98	973	120
31	308	38	65	645	79	99	983	121
32	318	39	66	655	81	100	993	122
33	327	40	67	665	82	200	1985	244
34	337	41	68	675	83	300	2977	366

M.	8 d.	82 d.
1	10	1
2	20	3
3	30	4
4	40	6
5	50	7
6	59	8
7	69	10
8	79	11
9	89	13
10	99	14
11	109	15
12	119	17
13	129	18
14	139	19
15	148	21
16	158	22
17	168	24
18	178	25
19	188	26
20	198	28
21	208	29
22	218	31
23	228	32
24	238	33
25	248	35
26	257	36
27	267	38
28	277	39
29	287	40
30	297	42
31	307	43
32	317	44
33	327	46
34	337	47

M.	8 d.	82 d.
35	347	49
36	357	50
37	366	51
38	376	53
39	386	54
40	396	56
41	406	57
42	416	58
43	426	60
44	436	61
45	446	63
46	456	64
47	366	65
48	475	67
49	485	68
50	495	70
51	505	71
52	515	72
53	525	74
54	535	75
55	545	77
56	555	78
57	565	79
58	574	81
59	584	82
60	594	83
61	604	85
62	614	86
63	624	88
64	634	89
65	644	90
66	654	92
67	664	93
68	674	95

Min.	8 d.	82 d.
69	683	90
70	693	97
71	703	99
72	713	100
73	723	102
74	733	103
75	743	104
76	753	106
77	763	107
78	772	109
79	782	110
80	792	111
81	802	113
82	812	114
83	822	115
84	832	117
85	842	118
86	852	120
87	862	121
88	872	122
89	881	124
90	891	125
91	901	127
92	911	128
93	921	129
94	931	131
95	941	132
96	951	134
97	961	135
98	970	136
99	980	138
100	990	139
200	1981	278
300	2971	418

M.	9 d.	81 d.
1	10	2
2	20	3
3	30	5
4	40	6
5	50	8
6	59	9
7	69	11
8	79	13
9	89	14
10	99	16
11	109	17
12	119	19
13	129	20
14	138	22
15	148	23
16	158	25
17	168	26
18	178	28
19	188	30
20	198	31
21	208	33
22	217	34
23	227	36
24	237	37
25	247	39
26	257	41
27	267	42
28	277	44
29	287	45
30	296	47
31	306	48
32	316	50
33	326	51
34	336	53

M.	9 d.	81 d.
35	346	55
36	356	56
37	366	58
38	375	59
39	385	61
40	395	63
41	405	64
42	415	66
43	425	67
44	435	69
45	445	70
46	454	72
47	364	73
48	474	75
49	484	77
50	494	78
51	504	80
52	514	81
53	524	83
54	534	84
55	543	86
56	553	88
57	563	89
58	573	91
59	583	92
60	593	94
61	603	95
62	612	97
63	622	98
64	632	100
65	642	102
66	652	103
67	662	105
68	672	106

Min.	9 d.	81 d.
69	682	108
70	691	109
71	701	111
72	711	112
73	721	114
74	731	116
75	741	117
76	751	119
77	761	120
78	770	122
79	780	124
80	790	125
81	800	127
82	810	128
83	820	130
84	830	131
85	840	133
86	850	134
87	859	136
88	869	138
89	879	139
90	889	141
91	899	142
92	909	144
93	919	145
94	929	147
95	938	148
96	948	150
97	958	152
98	968	153
99	978	155
100	988	156
200	1975	213
300	2963	369

M.	10 d.	80 d.
1	10	2
2	20	3
3	30	5
4	39	7
5	49	9
6	59	10
7	69	12
8	79	14
9	89	16
10	99	17
11	108	19
12	118	21
13	128	23
14	138	24
15	148	26
16	158	28
17	168	30
18	177	31
19	187	33
20	197	35
21	207	36
22	217	38
23	227	40
24	236	42
25	246	43
26	256	45
27	266	47
28	276	49
29	286	50
30	296	52
31	305	54
32	315	55
33	325	57
34	333	59

M.	10 d.	80 d.
35	345	61
36	355	62
37	365	74
38	374	76
39	384	78
40	394	79
41	404	71
42	414	73
43	424	75
44	433	76
45	443	78
46	453	80
47	463	81
48	473	83
49	483	85
50	492	87
51	502	88
52	512	90
53	522	92
54	532	94
55	542	95
56	552	97
57	561	99
58	571	101
59	581	102
60	591	104
61	601	106
62	610	108
63	620	19
64	630	111
65	640	113
66	650	115
67	660	116
68	670	118

Min.	10 d.	80 d.
69	680	120
70	689	121
71	799	123
72	709	125
73	719	127
74	729	128
75	739	130
76	749	132
77	758	133
78	768	135
79	778	137
80	788	139
81	898	141
82	808	142
83	817	144
84	827	146
85	837	148
86	847	149
87	857	151
88	867	153
89	876	154
90	886	156
91	896	158
92	906	161
93	916	161
94	926	163
95	936	165
96	946	167
97	955	168
98	965	170
99	975	172
100	985	174
200	1970	347
300	2954	521

M.	11d.	79d.
1	10	2
2	20	4
3	29	6
4	39	8
5	49	9
6	59	11
7	69	13
8	78	15
9	88	17
10	98	19
11	108	21
12	118	23
13	128	25
14	137	27
15	147	29
16	157	30
17	167	32
18	177	34
19	186	36
20	196	38
21	206	40
22	216	42
23	226	44
24	236	46
25	245	48
26	255	50
27	265	51
28	275	53
29	285	55
30	294	57
31	304	59
32	314	61
33	324	63
34	334	65

M.	11d.	79d.
35	343	67
36	353	69
37	363	71
38	373	72
39	383	74
40	493	76
41	402	78
42	412	80
43	422	82
44	432	84
45	442	86
46	452	88
47	461	90
48	471	92
49	481	93
50	591	95
51	501	97
52	510	99
53	520	101
54	530	103
55	540	105
56	550	107
57	559	109
58	569	111
59	579	112
60	589	114
61	599	116
62	609	118
63	618	120
64	628	122
65	638	124
66	648	126
67	658	128
68	668	130

Min.	11d.	79d.
69	677	132
70	687	134
71	797	135
72	707	137
73	716	139
74	726	141
75	736	143
76	746	145
77	756	147
78	765	149
79	775	151
80	785	153
81	895	154
82	805	156
83	815	158
84	824	160
85	834	165
86	844	164
87	854	166
88	864	168
89	873	170
90	883	172
91	893	174
92	903	176
93	913	177
94	923	179
95	932	181
96	942	183
97	952	185
98	962	187
99	972	189
100	981	191
200	1963	382
300	2944	572

M.	12d.	78d.
1	10	2
2	20	4
3	29	6
4	39	8
5	49	10
6	59	12
7	69	15
8	78	17
9	88	19
10	98	21
11	108	23
12	117	25
13	127	27
14	137	29
15	147	31
16	157	33
17	167	36
18	176	38
19	186	40
20	296	42
21	205	44
22	215	46
23	225	48
24	235	50
25	245	52
26	254	54
27	264	56
28	274	58
29	284	60
30	393	62
31	303	64
32	313	66
33	323	69
34	333	71

M.	12d.	78d.
35	342	73
36	352	75
37	362	77
38	372	79
39	381	81
40	491	83
41	401	85
42	411	87
43	420	90
44	430	92
45	440	94
46	450	96
47	460	98
48	470	100
49	479	102
50	589	104
51	599	106
52	509	108
53	518	110
54	528	112
55	538	114
56	548	116
57	558	118
58	567	121
59	577	123
60	687	125
61	697	127
62	607	129
63	616	131
64	626	133
65	636	135
66	646	137
67	655	140
68	665	142

Min.	12 d.	78 d.
69	675	144
70	685	146
71	695	148
72	704	150
73	714	152
74	724	154
75	734	156
76	744	158
77	753	160
78	763	162
79	773	164
80	783	166
81	792	168
82	802	170
83	812	173
84	822	175
85	831	177
86	841	179
87	851	181
88	861	183
89	871	185
90	880	187
91	890	189
92	900	191
93	910	193
94	920	195
95	929	197
96	939	200
97	949	202
98	959	204
99	968	206
100	978	208
200	1956	416
300	2934	624

M.	11d.	79d.
1	10	2
2	20	4
3	29	6
4	39	8
5	49	9
6	59	11
7	69	13
8	78	15
9	88	17
10	98	19
11	108	21
12	118	23
13	128	25
14	137	27
15	147	29
16	157	30
17	167	32
18	177	34
19	186	36
20	196	38
21	206	40
22	216	42
23	226	44
24	236	46
25	245	48
26	255	50
27	265	51
28	275	53
29	285	55
30	294	57
31	304	59
32	314	61
33	324	63
34	334	65

M.	11d.	79d.
35	343	67
36	353	69
37	363	71
38	373	72
39	383	74
40	493	76
41	402	78
42	412	80
43	422	82
44	432	84
45	442	86
46	452	88
47	461	90
48	471	92
49	481	93
50	591	95
51	501	97
52	510	99
53	520	101
54	530	103
55	540	105
56	550	107
57	559	109
58	569	111
59	579	112
60	589	114
61	599	116
62	609	118
63	618	120
64	628	122
65	638	124
66	648	126
67	658	128
68	668	130

Min.	11d.	79d.
69	677	132
70	687	134
71	797	135
72	707	137
73	716	139
74	726	141
75	736	143
76	746	145
77	756	147
78	765	149
79	775	151
80	785	153
81	895	154
82	805	156
83	815	158
84	824	160
85	834	165
86	844	164
87	854	166
88	864	168
89	873	170
90	883	172
91	893	174
92	903	176
93	913	177
94	923	179
95	932	181
96	942	183
97	952	185
98	962	187
99	972	189
100	981	191
200	1963	382
300	2944	572

M.	12d.	78d.
1	10	2
2	20	4
3	29	6
4	39	8
5	49	10
6	59	12
7	69	15
8	78	17
9	88	19
10	98	21
11	108	23
12	117	25
13	127	27
14	137	29
15	147	31
16	157	33
17	167	36
18	176	38
19	186	40
20	296	42
21	205	44
22	215	46
23	225	48
24	235	50
25	245	52
26	254	54
27	264	56
28	274	58
29	284	60
30	393	62
31	303	64
32	313	66
33	323	69
34	333	71

M.	12d.	78d.
35	342	73
36	352	75
37	362	77
38	372	79
39	381	81
40	491	83
41	401	85
42	411	87
43	420	90
44	430	92
45	440	94
46	450	96
47	460	98
48	470	100
49	479	102
50	589	104
51	599	106
52	509	108
53	518	110
54	528	112
55	538	114
56	548	116
57	558	118
58	567	121
59	577	123
60	687	125
61	697	127
62	607	129
63	616	131
64	626	133
65	636	135
66	646	137
67	655	140
68	665	142

Min.	12 d.	78 d.
69	675	144
70	685	146
71	694	148
72	704	150
73	714	152
74	724	154
75	734	156
76	744	158
77	753	160
78	763	162
79	773	164
80	783	166
81	792	168
82	802	170
83	812	173
84	822	175
85	831	177
86	841	179
87	851	181
88	861	183
89	871	185
90	880	187
91	890	189
92	900	191
93	910	193
94	920	195
95	929	197
96	939	200
97	949	202
98	959	204
99	968	206
100	978	208
200	1956	416
300	2934	624

M.	13 d.	77 d.
1	10	2
2	20	4
3	29	7
4	39	9
5	49	11
6	59	13
7	68	16
8	78	18
9	88	20
10	98	22
11	107	25
12	117	27
13	127	29
14	136	31
15	146	34
16	156	36
17	166	38
18	176	40
19	185	43
20	195	45
21	205	47
22	215	49
23	224	52
24	234	54
25	244	56
26	254	58
27	263	61
28	273	63
29	283	65
30	292	67
31	302	70
32	312	72
33	322	74
34	331	76

M.	13 d.	77 d.
35	341	79
36	351	81
37	361	83
38	370	86
39	380	88
40	390	90
41	400	92
42	409	94
43	419	97
44	429	99
45	438	101
46	448	103
47	458	106
48	468	108
49	478	110
50	477	112
51	597	115
52	507	117
53	516	119
54	526	121
55	536	124
56	546	126
57	555	128
58	565	130
59	575	133
60	585	135
61	594	137
62	604	140
63	614	142
64	624	144
65	634	146
66	643	148
67	653	151
68	663	153

Min.	13 d.	77 d.
69	672	155
70	682	157
71	692	160
72	702	162
73	711	164
74	721	166
75	731	169
76	741	171
77	750	173
78	760	175
79	770	178
80	780	180
81	789	182
82	799	184
83	809	187
84	818	189
85	828	191
86	838	193
87	848	106
88	857	198
89	867	200
90	877	202
91	887	205
92	896	207
93	906	209
94	916	211
95	926	214
96	935	216
97	945	218
98	955	221
99	965	223
100	974	225
200	1949	450
300	2923	675

M.	14d.	76d.
1	10	2
2	19	5
3	29	7
4	39	10
5	48	12
6	58	14
7	68	17
8	78	19
9	87	22
10	97	24
11	107	27
12	116	29
13	126	31
14	136	34
15	146	36
16	155	39
17	165	41
18	175	44
19	184	46
20	194	48
21	204	51
22	213	53
23	223	56
24	233	58
25	242	60
26	252	63
27	262	65
28	272	68
29	281	70
30	291	73
31	301	75
32	310	77
33	320	80
34	330	82

M.	14d.	76d.
35	340	85
36	349	87
37	359	90
38	369	92
39	378	94
40	388	97
41	398	99
42	407	102
43	417	104
44	427	107
45	437	109
46	446	111
47	456	114
48	466	116
49	475	119
50	485	121
51	495	123
52	504	126
53	514	128
54	524	131
55	534	133
56	543	136
57	553	138
58	563	140
59	572	143
60	582	145
61	592	148
62	601	150
63	611	153
64	621	155
65	631	157
66	640	160
67	650	162
68	660	165

Min.	14 d.	76d.
69	669	167
70	679	169
71	689	172
72	698	174
73	708	177
74	718	179
75	728	182
76	737	184
77	747	187
78	757	189
79	766	191
80	776	194
81	786	195
82	796	197
83	805	200
84	815	202
85	825	205
86	834	207
87	844	209
88	854	213
89	864	215
90	873	218
91	883	220
92	893	223
93	902	225
94	912	227
95	921	230
96	931	232
97	941	235
98	951	237
99	960	240
100	970	242
200	1941	484
300	2911	726

M.	13d.	77d.	M.	13d.	77d.	Min.	13 d.	77 d.
1	10	2	35	341	79	69	672	155
2	20	4	36	351	81	70	682	157
3	29	7	37	361	83	71	692	160
4	39	9	38	370	86	72	702	162
5	49	11	39	380	88	73	711	164
6	59	13	40	390	90	74	721	166
7	68	16	41	400	92	75	731	169
8	78	18	42	409	94	76	741	171
9	88	20	43	419	97	77	750	173
10	98	22	44	429	99	78	760	175
11	107	25	45	438	101	79	770	178
12	117	27	46	448	103	80	780	180
13	127	29	47	458	106	81	789	182
14	136	31	48	468	108	82	799	184
15	146	34	49	478	110	83	809	187
16	156	36	50	477	112	84	818	189
17	166	38	51	597	115	85	828	191
18	176	40	52	507	117	86	838	193
19	185	43	53	516	119	87	848	106
20	195	45	54	526	121	88	857	198
21	205	47	55	536	124	89	867	200
22	215	49	56	546	126	90	877	202
23	224	52	57	555	128	91	887	205
24	234	54	58	565	130	92	896	207
25	244	56	59	575	133	93	906	209
26	254	58	60	585	135	94	916	211
27	263	61	61	594	137	95	926	214
28	273	63	62	604	140	96	935	216
29	283	65	63	614	142	97	945	218
30	292	67	64	624	144	98	955	221
31	303	70	65	634	146	99	965	223
32	312	72	66	643	148	100	974	225
33	322	74	67	653	151	200	1949	450
34	331	76	68	663	153	300	2923	675

M.	14 d.	76 d.	M.	14 d.	76 d.	Min.	14 d.	76 d.
1	10	2	35	340	85	69	669	167
2	19	5	36	349	87	70	679	169
3	29	7	37	359	90	71	689	172
4	39	10	38	369	92	72	698	174
5	48	12	39	378	94	73	708	177
6	58	14	40	388	97	74	718	179
7	68	17	41	398	99	75	728	182
8	78	19	42	407	102	76	737	184
9	87	22	43	417	104	77	747	187
10	97	24	44	427	107	78	757	189
11	107	27	45	437	109	79	766	191
12	116	29	46	446	111	80	776	194
13	126	31	47	456	114	81	786	195
14	136	34	48	466	116	82	796	197
15	146	36	49	475	119	83	805	200
16	155	39	50	485	121	84	815	202
17	165	41	51	495	123	85	825	205
18	175	44	52	504	126	86	834	207
19	184	46	53	514	128	87	844	209
20	194	48	54	524	131	88	854	213
21	204	51	55	534	133	89	864	215
22	213	53	56	543	136	90	873	218
23	223	56	57	553	138	91	883	220
24	233	58	58	563	140	92	893	223
25	242	60	59	572	143	93	902	225
26	252	63	60	582	145	94	912	227
27	262	65	61	592	148	95	921	230
28	272	68	62	601	150	96	931	232
29	281	70	63	611	153	97	941	235
30	291	73	64	621	155	98	951	237
31	301	75	65	631	157	99	960	240
32	310	77	66	640	160	100	970	242
33	320	80	67	650	162	200	1941	484
34	330	82	68	660	165	300	2911	726

M.	15 d.	75 d.
1	10	3
2	19	5
3	29	8
4	39	10
5	48	13
6	58	16
7	68	18
8	77	21
9	87	23
10	97	26
11	106	28
12	116	31
13	126	34
14	135	36
15	145	39
16	155	41
17	164	44
18	174	47
19	183	49
20	193	52
21	203	54
22	213	57
23	222	60
24	232	62
25	242	65
26	251	67
27	261	70
28	271	73
29	280	75
30	290	78
31	399	80
32	309	83
33	319	85
34	328	88

M.	15 d.	75 d.
35	338	91
36	348	93
37	357	96
38	367	98
39	377	101
40	386	103
41	396	106
42	406	109
43	415	111
44	425	114
45	435	116
46	444	119
47	454	123
48	464	125
49	473	128
50	483	129
51	493	132
52	502	135
53	512	137
54	522	140
55	531	142
56	541	145
57	551	148
58	560	150
59	570	153
60	580	155
61	589	158
62	599	160
63	608	163
64	618	166
65	628	168
66	638	171
67	647	174
68	657	176

Min.	15 d.	75 d.
69	666	179
70	676	181
71	686	184
72	696	186
73	705	189
74	715	192
75	724	194
76	734	197
77	744	200
78	754	202
79	763	205
80	773	207
81	783	210
82	792	212
83	802	215
84	811	217
85	821	220
86	831	223
87	840	225
88	850	228
89	860	230
90	869	233
91	879	236
92	889	238
93	898	241
94	908	243
95	918	246
96	927	248
97	937	251
98	947	254
99	956	256
100	966	259
200	1932	518
300	2898	776

M.	16d.	74d.
1	10	3
2	19	6
3	29	8
4	38	11
5	48	14
6	58	17
7	67	19
8	77	22
9	86	25
10	96	28
11	106	30
12	115	33
13	125	36
14	134	39
15	144	41
16	154	44
17	163	47
18	173	50
19	183	53
20	192	55
21	202	58
22	212	61
23	221	63
24	231	66
25	240	69
26	250	72
27	259	75
28	269	77
29	279	80
30	288	83
31	298	85
32	308	88
33	317	91
34	327	94

M.	16d.	74d.
35	336	97
36	345	99
37	356	102
38	365	105
39	375	107
40	384	110
41	394	113
42	404	116
43	413	119
44	423	121
45	432	124
46	442	127
47	452	130
48	461	132
49	471	135
50	481	138
51	490	141
52	500	143
53	509	146
54	519	149
55	539	151
56	528	154
57	548	157
58	557	160
59	567	163
60	577	165
61	586	168
62	596	171
63	606	174
64	615	177
65	625	179
66	634	182
67	644	185
68	654	188

Min.	16d.	74 d.
69	663	190
70	673	193
71	682	196
72	692	199
73	702	201
74	711	204
75	721	207
76	731	210
77	740	213
78	750	215
79	759	218
80	769	220
81	779	223
82	788	226
83	798	229
84	807	232
85	817	235
86	827	237
87	836	240
88	846	243
89	856	245
90	865	248
91	875	251
92	984	254
93	994	257
94	904	259
95	913	262
96	923	265
97	932	267
98	942	270
99	952	273
100	961	276
200	1925	551
300	2884	827

M.	17d.	73d.
1	10	3
2	19	6
3	29	9
4	38	12
5	48	15
6	57	17
7	67	20
8	76	23
9	86	26
10	96	29
11	105	32
12	115	35
13	124	38
14	134	41
15	143	44
16	153	47
17	162	50
18	172	52
19	182	55
20	191	58
21	201	61
22	210	64
23	220	67
24	230	70
25	239	73
26	249	76
27	258	79
28	268	82
29	277	85
30	287	88
31	296	91
32	306	93
33	316	96
34	325	99

M.	17d.	73d.
35	335	102
36	344	105
37	354	108
38	363	111
39	373	114
40	383	117
41	392	120
42	402	123
43	411	126
44	421	129
45	430	131
46	440	134
47	449	137
48	459	140
49	469	143
50	478	146
51	488	149
52	497	152
53	507	155
54	516	158
55	526	161
56	535	164
57	545	167
58	554	170
59	564	172
60	574	175
61	583	178
62	593	181
63	602	184
64	612	187
65	622	190
66	631	193
67	643	196
68	650	199

Min.	17d.	73d.
69	664	202
70	663	205
71	673	207
72	682	210
73	791	213
74	701	216
75	710	219
76	729	222
77	739	225
78	748	228
79	757	231
80	767	234
81	776	237
82	786	240
83	795	243
84	804	246
85	814	248
86	823	251
87	832	254
88	842	257
89	851	260
90	860	263
91	979	266
92	989	269
93	988	275
94	997	276
95	907	278
96	916	281
97	925	284
98	935	287
99	954	289
100	964	292
200	1927	585
300	2881	877

M.	18d.	72d.
1	10	3
2	19	6
3	28	9
4	38	12
5	47	15
6	57	18
7	66	22
8	76	25
9	85	28
10	95	31
11	104	34
12	114	37
13	123	40
14	133	43
15	142	46
16	152	50
17	161	53
18	171	56
19	180	59
20	190	62
21	200	65
22	209	68
23	219	71
24	228	74
25	238	77
26	247	81
27	257	84
28	266	87
29	276	90
30	285	93
31	295	96
32	304	99
33	314	102
34	323	105

M.	18d.	72d.
35	333	108
36	342	111
37	352	114
38	361	117
39	371	120
40	380	124
41	390	127
42	398	130
43	408	133
44	417	136
45	427	139
46	436	142
47	446	145
48	455	148
49	465	151
50	476	154
51	485	158
52	495	161
53	504	164
54	514	167
55	523	170
56	533	173
57	542	176
58	552	179
59	561	182
60	571	185
61	580	188
62	598	192
63	599	195
64	609	198
65	618	201
66	628	204
67	637	207
68	647	210

Min.	18 d.	72 d.
69	656	213
70	666	216
71	675	219
72	685	222
73	694	225
74	704	229
75	713	232
76	723	235
77	732	238
78	742	241
79	751	244
80	761	247
81	770	250
82	780	253
83	789	256
84	799	260
85	808	263
86	818	266
87	827	269
88	837	272
89	846	275
90	856	278
91	865	281
92	875	284
93	884	287
94	894	290
95	903	293
96	913	297
97	922	300
98	932	303
99	941	306
100	951	309
200	1903	618
300	2850	927

M.	19d.	71d.
1	9	3
2	19	6
3	28	10
4	38	13
5	47	16
6	57	20
7	66	23
8	75	26
9	85	29
10	94	33
11	104	36
12	113	39
13	123	42
14	132	46
15	142	49
16	151	52
17	161	55
18	170	59
19	180	62
20	189	65
21	199	68
22	208	72
23	217	75
24	227	78
25	236	82
26	246	85
27	255	88
28	265	91
29	274	94
30	284	98
31	293	101
32	303	104
33	312	107
34	321	111

M.	19d.	71d.
35	331	114
36	340	117
37	350	121
38	359	124
39	369	127
40	378	130
41	388	134
42	397	137
43	407	140
44	416	143
45	425	147
46	435	150
47	444	153
48	454	156
49	463	160
50	473	163
51	482	166
52	492	169
53	501	173
54	510	176
55	520	179
56	539	182
57	549	186
58	558	189
59	568	192
60	577	195
61	587	199
62	696	202
63	606	205
64	615	208
65	625	212
66	634	215
67	644	218
68	653	222

Min.	19 d.	81 d.
69	652	225
70	662	228
71	671	231
72	681	234
73	690	238
74	699	241
75	709	244
76	718	247
77	728	251
78	737	254
79	747	257
80	756	261
81	766	264
82	775	267
83	785	270
84	794	274
85	804	277
86	813	280
87	822	283
88	832	287
89	841	290
90	851	293
91	860	296
92	870	300
93	879	303
94	889	306
95	898	309
96	908	313
97	917	316
98	926	319
99	936	322
100	945	326
200	1891	651
300	2836	977

M.	20 d.	70 d.
1	9	3
2	19	7
3	28	10
4	38	14
5	47	17
6	56	20
7	66	24
8	75	27
9	85	31
10	94	34
11	103	38
12	113	41
13	122	44
14	132	48
15	141	51
16	150	55
17	160	58
18	169	61
19	179	65
20	188	68
21	197	72
22	207	75
23	216	79
24	226	82
25	235	85
26	244	89
27	254	92
28	263	96
29	272	100
30	282	103
31	291	106
32	301	109
33	310	113
34	319	116
35	329	120
36	338	123
37	348	126
38	357	130
39	366	133
40	376	137
41	385	140
42	395	144
43	404	147
44	413	150
45	423	154
46	432	157
47	442	161
48	451	164
49	460	168
50	470	171
51	479	174
52	489	178
53	498	181
54	507	185
55	517	188
56	526	191
57	536	195
58	545	198
59	554	202
60	564	205
61	573	209
62	583	212
63	592	215
64	602	219
65	611	222
66	620	226
67	630	229
68	639	233

Min.	20 d.	70 d.
69	648	236
70	658	239
71	667	243
72	677	246
73	686	250
74	695	253
75	705	256
76	714	260
77	724	263
78	733	267
79	742	270
80	752	274
81	761	277
82	771	280
83	780	284
84	799	287
85	800	291
86	808	294
87	818	298
88	827	301
89	836	304
90	846	308
91	855	311
92	864	315
93	874	318
94	883	321
95	893	325
96	902	328
97	912	332
98	921	335
99	930	339
100	940	342
200	1879	684
300	2819	1026

M.	21 d.	69 d.
1	9	4
2	19	7
3	28	11
4	37	14
5	47	18
6	56	21
7	65	25
8	75	29
9	84	32
10	93	36
11	103	39
12	112	43
13	121	47
14	131	50
15	140	54
16	149	57
17	159	61
18	168	64
19	177	68
20	187	72
21	196	75
22	205	79
23	215	82
24	224	86
25	233	90
26	242	93
27	252	97
28	261	100
29	271	104
30	280	107
31	289	111
32	298	115
33	309	118
34	327	112

M.	21 d.	69 d.
35	327	125
36	336	129
37	345	132
38	355	136
39	364	140
40	373	143
41	383	147
42	392	150
43	401	154
44	411	158
45	420	161
46	439	165
47	449	168
48	458	172
49	467	176
50	477	179
51	476	183
52	485	186
53	495	190
54	504	193
55	513	197
56	523	201
57	532	204
58	542	208
59	551	211
60	560	215
61	569	219
62	579	222
63	588	226
64	698	229
65	607	233
66	616	236
67	626	240
68	635	244

Min.	21 d.	69 d.
69	644	247
70	653	251
71	663	254
72	672	258
73	681	262
74	691	265
75	700	269
76	709	272
77	719	276
78	728	279
79	737	283
80	747	287
81	756	290
82	766	294
83	775	297
84	784	301
85	794	305
86	803	308
87	812	312
88	822	315
89	831	319
90	840	323
91	849	326
92	859	330
93	868	333
94	877	337
95	887	340
96	896	344
97	905	348
98	915	351
99	924	355
100	934	358
200	1867	717
300	1801	1075

M.	22 d.	68 d.	M.	22 d.	68 d.	Min.	22 d.	68 d.
1	9	4	35	324	131	69	640	259
2	19	7	36	334	135	70	649	262
3	28	11	37	343	139	71	658	266
4	37	15	38	352	142	72	667	270
5	46	19	39	361	146	73	677	274
6	56	22	40	371	150	74	686	277
7	65	26	41	380	154	75	695	281
8	74	30	42	389	157	76	705	285
9	83	34	43	399	161	77	714	289
10	93	37	44	408	165	78	723	292
11	102	41	45	417	169	79	733	296
12	111	45	46	426	172	80	742	300
13	120	49	47	436	176	81	751	304
14	130	52	48	445	180	82	760	307
15	139	56	49	454	184	83	770	311
16	148	60	50	464	187	84	779	315
17	157	64	51	473	191	85	788	329
18	167	67	52	482	195	86	797	322
19	176	71	53	491	199	87	806	326
20	185	75	54	501	202	88	816	330
21	195	79	55	510	206	89	825	334
22	204	82	56	519	210	90	834	337
23	213	86	57	529	214	91	844	341
24	222	90	58	538	217	92	853	345
25	232	94	59	547	221	93	862	349
26	241	97	60	556	225	94	871	352
27	250	101	61	566	229	95	881	356
28	260	105	62	575	232	96	890	360
29	269	109	63	584	236	97	899	364
30	278	112	64	594	240	98	909	367
31	287	116	65	603	244	99	918	371
32	297	120	66	612	247	100	927	375
33	306	124	67	621	251	200	854	749
34	315	127	68	631	255	300	782	1095

M.	23 d.	67 d.
1	9	4
2	18	8
3	28	12
4	37	16
5	46	19
6	55	23
7	64	27
8	74	31
9	83	35
10	92	39
11	101	43
12	110	47
13	120	51
14	129	55
15	138	59
16	147	62
17	156	66
18	166	70
19	175	74
20	184	78
21	193	82
22	202	86
23	212	90
24	221	94
25	230	98
26	239	102
27	248	105
28	258	109
29	267	113
30	276	117
31	285	121
32	294	125
33	304	129
34	313	133

M.	23 d.	67 d.
35	322	137
36	331	141
37	340	144
38	350	148
39	359	152
40	368	156
41	377	160
42	386	164
43	396	168
44	405	172
45	414	176
46	423	180
47	433	184
48	442	187
49	451	191
50	460	195
51	469	199
52	479	203
53	488	207
54	497	211
55	506	215
56	515	219
57	524	223
58	534	226
59	543	230
60	552	234
61	561	238
62	571	242
63	580	246
64	589	250
65	598	258
66	608	254
67	618	262
68	626	266

Min.	23 d.	67 d.
69	635	269
70	644	273
71	653	277
72	663	281
73	672	285
74	681	289
75	690	293
76	699	297
77	709	301
78	718	305
79	727	308
80	736	312
81	746	316
82	755	320
83	764	324
84	773	328
85	782	332
86	792	336
87	801	340
88	810	344
89	819	348
90	828	352
91	838	356
92	847	360
93	856	363
94	865	367
95	874	370
96	884	375
97	893	379
98	902	383
99	911	397
100	920	391
200	1841	781
300	1761	1172

M.	24d.	66d.
1	9	4
2	18	8
3	27	12
4	36	16
5	46	20
6	55	24
7	64	28
8	73	32
9	82	37
10	91	41
11	100	45
12	109	49
13	119	53
14	128	57
15	137	61
16	146	65
17	155	69
18	164	73
19	173	77
20	182	81
21	192	85
22	201	90
23	210	94
24	219	98
25	228	102
26	237	106
27	246	110
28	256	113
29	265	117
30	274	122
31	283	126
32	292	130
33	301	134
34	310	138

M.	24d.	66d.
35	320	142
36	329	146
37	338	151
38	347	155
39	356	159
40	365	163
41	374	167
42	384	171
43	393	175
44	402	179
45	411	183
46	420	187
47	429	191
48	438	195
49	448	199
50	457	203
51	466	207
52	475	211
53	484	216
54	493	220
55	502	224
56	511	228
57	521	232
58	530	236
59	539	240
60	548	244
61	557	248
62	566	252
63	575	256
64	585	260
65	594	264
66	603	268
67	612	272
68	621	276

Min.	24d.	66 d.
69	630	281
70	639	285
71	648	289
72	658	293
73	667	297
74	676	301
75	685	305
76	694	309
77	703	313
78	712	317
79	721	321
80	731	325
81	740	329
82	749	333
83	758	337
84	767	341
85	776	345
86	785	349
87	795	353
88	804	357
89	813	362
90	822	366
91	831	370
92	840	374
93	849	378
94	858	382
95	868	386
96	877	390
97	886	395
98	895	399
99	904	403
100	913	407
200	1827	813
300	2740	1220

M.	25d.	65d.
1	9	4
2	18	8
3	27	13
4	36	17
5	45	21
6	54	25
7	63	30
8	72	34
9	81	38
10	91	42
11	100	47
12	119	51
13	118	55
14	127	59
15	136	63
16	145	68
17	154	72
18	163	76
19	172	80
20	181	84
21	190	89
22	199	93
23	208	97
24	218	101
25	227	106
26	236	110
27	245	114
28	254	118
29	263	123
30	272	127
31	281	131
32	290	135
33	299	140
34	308	144

M.	25d.	65d.
35	317	140
36	326	152
37	335	156
38	344	161
39	353	165
40	362	169
41	372	173
42	381	178
43	390	182
44	399	186
45	408	190
46	417	195
47	426	199
48	435	203
49	444	207
50	453	211
51	462	216
52	471	220
53	480	224
54	489	228
55	498	232
56	507	237
57	516	241
58	526	245
59	535	250
60	544	254
61	553	258
62	562	262
63	571	267
64	580	271
65	589	275
66	598	279
67	607	283
68	616	288

Min.	25 d.	65 d.
69	625	292
70	634	296
71	643	300
72	652	305
73	661	309
74	671	313
75	680	317
76	689	321
77	698	326
78	707	330
79	716	334
80	725	338
81	734	343
82	743	347
83	752	351
84	761	355
85	770	360
86	779	364
87	788	368
88	797	372
89	807	376
90	816	380
91	825	384
92	834	389
93	843	393
94	852	398
95	861	401
96	870	406
97	879	410
98	888	414
99	897	418
100	906	423
200	1813	845
300	2719	1268

M.	26 d	64 d.
1	9	4
2	18	9
3	27	13
4	36	18
5	45	22
6	54	26
7	63	31
8	72	35
9	81	39
10	90	44
11	99	48
12	108	53
13	117	57
14	126	61
15	135	66
16	144	70
17	153	74
18	162	79
19	171	83
20	180	88
21	189	92
22	198	96
23	207	101
24	216	105
25	225	109
26	234	114
27	243	118
28	252	123
29	261	127
30	270	131
31	279	136
32	288	140
33	297	144
34	306	149

M.	26 d.	64 d.
35	315	153
36	324	158
37	333	162
38	342	166
39	351	171
40	360	175
41	368	179
42	378	184
43	386	188
44	395	192
45	404	197
46	413	202
47	422	206
48	431	210
49	440	214
50	449	219
51	458	223
52	467	228
53	476	232
54	485	237
55	494	241
56	503	245
57	512	250
58	521	254
59	530	258
60	539	263
61	548	267
62	557	272
63	566	276
64	575	280
65	584	285
66	593	289
67	602	294
68	611	298

Min.	26 d.	64 d.
69	620	302
70	629	307
71	638	311
72	647	316
73	656	320
74	665	324
75	674	329
76	683	333
77	692	338
78	701	342
79	710	346
80	719	351
81	728	355
82	737	359
83	746	364
84	755	368
85	764	372
86	773	377
87	782	381
88	791	385
89	800	340
90	809	394
91	818	399
92	827	403
93	836	407
94	845	412
95	854	416
96	863	421
97	872	425
98	881	429
99	890	434
100	899	438
200	1798	877
300	2696	1315

M.	27 d.	63 d.	M.	27 d.	63 d.	Min.	27 d.	63 d.
1	9	5	35	312	159	69	615	313
2	18	9	36	321	163	70	624	318
3	27	14	37	330	168	71	633	322
4	36	18	38	338	172	72	641	327
5	45	23	39	347	177	73	650	332
6	53	27	40	356	182	74	659	336
7	62	32	41	365	186	75	668	341
8	71	36	42	374	191	76	677	345
9	80	41	43	383	195	77	686	350
10	89	45	44	391	200	78	695	354
11	98	50	45	401	204	79	704	359
12	107	54	46	410	209	80	713	363
13	116	59	47	419	213	81	722	368
14	125	63	48	428	218	82	731	372
15	134	68	49	436	222	83	739	377
16	143	72	50	445	227	84	748	381
17	151	77	51	454	232	85	757	386
18	160	82	52	463	236	86	766	390
19	169	86	53	472	241	87	774	395
20	178	91	54	481	245	88	784	400
21	187	95	55	490	250	89	793	404
22	196	100	56	499	254	90	802	409
23	205	104	57	508	259	91	811	413
24	214	109	58	517	263	92	820	418
25	223	113	59	526	268	93	829	422
26	232	118	60	535	272	94	837	427
27	241	122	61	543	277	95	846	431
28	249	127	62	552	282	96	855	436
29	258	132	63	561	286	97	864	440
30	267	136	64	570	291	98	873	445
31	276	141	65	579	295	99	882	449
32	285	145	66	588	300	100	891	454
33	294	150	67	597	304	200	1782	909
34	303	154	68	606	309	300	2673	1363

M.	28 d.	62 d.
1	9	5
2	18	9
3	26	14
4	35	19
5	44	23
6	53	28
7	62	33
8	71	37
9	79	42
10	88	47
11	97	52
12	106	56
13	115	61
14	124	66
15	132	70
16	141	75
17	150	80
18	159	84
19	168	89
20	177	94
21	185	99
22	194	103
23	203	108
24	212	113
25	221	117
26	230	122
27	238	127
28	247	131
29	256	136
30	265	141
31	274	145
32	282	150
33	291	155
34	300	160

M.	28 d.	62 d.
35	309	164
36	318	169
37	326	174
38	335	178
39	344	183
40	353	188
41	362	192
42	371	197
43	380	202
44	388	207
45	397	211
46	406	216
47	415	221
48	424	225
49	432	230
50	441	235
51	450	239
52	459	243
53	468	249
54	477	254
55	485	258
56	494	263
57	503	268
58	512	272
59	521	277
60	530	282
61	538	286
62	547	291
63	556	296
64	565	300
65	574	305
66	583	310
67	591	315
68	600	319

Min.	28 d.	62 d.
69	609	324
70	618	326
71	627	333
72	636	338
73	644	343
74	653	347
75	662	352
76	671	357
77	680	361
78	689	366
79	997	371
80	706	376
81	715	380
82	724	385
83	733	390
84	742	394
85	750	399
86	759	404
87	768	408
88	777	413
89	786	418
90	795	422
91	803	427
92	812	432
93	821	437
94	830	441
95	839	446
96	848	451
97	856	455
98	865	460
99	874	465
100	883	469
200	1766	939
300	2649	1408

M.	29d.	61d.
1	9	5
2	17	10
3	26	14
4	35	19
5	44	24
6	52	29
7	61	34
8	70	39
9	79	43
10	87	48
11	96	53
12	105	58
13	114	63
14	122	68
15	131	73
16	140	77
17	149	82
18	157	87
19	166	92
20	175	97
21	184	102
22	192	107
23	201	111
24	210	116
25	219	121
26	227	126
27	236	131
28	245	136
29	254	141
30	262	145
31	271	150
32	280	155
33	289	160
34	297	165

M.	29d.	61d.
35	306	170
36	315	174
37	324	179
38	332	184
39	341	189
40	350	194
41	359	199
42	367	203
43	376	208
44	385	213
45	394	218
46	402	223
47	411	228
48	420	233
49	429	237
50	437	242
51	446	247
52	455	252
53	464	257
54	472	262
55	481	267
56	490	271
57	499	276
58	516	281
59	525	286
60	534	291
61	533	296
62	542	301
63	551	305
64	560	310
65	569	315
66	577	320
67	586	325
68	595	330

Min.	29 d.	61 d.
69	604	334
70	612	339
71	621	344
72	630	349
73	638	354
74	647	359
75	656	363
76	665	368
77	673	373
78	682	378
79	691	383
80	700	388
81	708	393
82	717	397
83	726	402
84	735	407
85	743	412
86	752	417
87	761	422
88	770	427
89	778	431
90	787	436
91	796	441
92	805	446
93	813	451
94	822	456
95	831	461
96	840	465
97	848	470
98	857	475
99	866	480
100	875	485
200	1749	970
300	2624	1454

M.	30d.	60d.
1	9	5
2	17	10
3	26	15
4	35	20
5	43	25
6	52	30
7	61	35
8	69	40
9	78	45
10	87	50
11	95	55
12	104	60
13	113	65
14	121	70
15	130	75
16	139	80
17	147	85
18	156	90
19	165	95
20	173	100
21	182	105
22	191	110
23	199	115
24	208	120
25	217	125
26	225	130
27	234	135
28	242	140
29	251	145
30	260	150
31	268	155
32	277	160
33	286	165
34	294	170

M.	30d.	60d.
35	303	175
36	312	180
37	320	185
38	329	190
39	338	195
40	346	200
41	355	205
42	364	210
43	372	215
44	381	220
45	390	225
46	398	230
47	407	235
48	416	240
49	424	245
50	433	250
51	442	255
52	450	260
53	459	265
54	468	270
55	476	275
56	485	280
57	494	285
58	502	290
59	511	295
60	520	300
61	528	305
62	537	310
63	546	315
64	554	320
65	563	325
66	572	330
67	580	335
68	589	340

Min.	30 d.	60 d.
69	598	345
70	606	350
71	615	355
72	623	360
73	632	365
74	641	370
75	649	375
76	658	380
77	667	385
78	676	390
79	684	395
80	693	400
81	702	405
82	710	410
83	719	415
84	727	420
85	736	425
86	745	430
87	753	435
88	762	440
89	771	445
90	779	450
91	788	455
92	797	460
93	806	465
94	814	470
95	823	475
96	832	480
97	840	485
98	849	490
99	857	495
100	866	500
200	1732	1000
300	2598	1500

M.	31 d.	59 d.
1	9	5
2	17	10
3	26	15
4	34	21
5	43	26
6	51	31
7	60	36
8	79	41
9	87	46
10	96	51
11	94	57
12	103	62
13	111	67
14	120	72
15	129	77
16	137	82
17	146	88
18	154	93
19	163	98
20	171	103
21	180	108
22	189	113
23	197	118
24	206	124
25	214	129
26	223	134
27	231	139
28	240	144
29	249	149
30	257	154
31	266	160
32	274	165
33	283	170
34	292	174

M.	31 d.	59 d.
35	300	180
36	309	185
37	317	191
38	326	196
39	334	201
40	343	206
41	351	211
42	360	216
43	369	221
44	377	227
45	386	232
46	394	237
47	403	242
48	411	247
49	420	252
50	429	257
51	437	263
52	446	268
53	454	273
54	463	278
55	471	283
56	480	288
57	489	294
58	497	299
59	506	304
60	514	309
61	523	314
62	531	319
63	540	324
64	549	330
65	557	335
66	566	340
67	574	345
68	583	350

Min.	31 d.	59 d.
69	591	355
70	600	360
71	609	366
72	617	371
73	626	376
74	634	381
75	643	386
76	651	391
77	660	397
78	669	402
79	677	407
80	686	412
81	694	417
82	703	422
83	711	427
84	720	433
85	729	438
86	737	443
87	746	448
88	754	453
89	763	458
90	771	463
91	780	469
92	789	474
93	797	479
94	806	484
95	814	489
96	823	494
97	831	500
98	840	505
99	849	510
100	857	515
200	1714	1030
300	2572	1545

M.	32d	58d.
1	8	5
2	17	11
3	25	16
4	34	21
5	42	26
6	51	32
7	59	37
8	68	42
9	76	48
10	85	53
11	93	58
12	102	64
13	110	69
14	119	74
15	127	79
16	136	85
17	144	90
18	153	95
19	161	101
20	170	106
21	178	111
22	187	117
23	195	122
24	204	127
25	212	132
26	220	138
27	229	143
28	237	148
29	249	153
30	254	159
31	263	164
32	271	170
33	280	175
34	288	180

M.	32d.	58d.
35	297	185
36	305	191
37	314	196
38	322	201
39	331	207
40	339	212
41	348	217
42	356	223
43	365	228
44	373	233
45	382	238
46	390	244
47	398	249
48	407	254
49	415	260
50	424	265
51	432	270
52	441	275
53	449	281
54	458	286
55	466	291
56	475	297
57	483	302
58	492	307
59	500	313
60	509	318
61	517	323
62	526	329
63	534	334
64	543	339
65	551	344
66	560	350
67	568	355
68	577	360

Min.	32 d.	58 d.
69	585	366
70	594	371
71	602	376
72	610	381
73	619	387
74	627	392
75	636	397
76	644	403
77	653	408
78	761	413
79	670	419
80	678	424
81	687	429
82	695	434
83	703	440
84	712	445
85	721	450
86	729	456
87	738	461
88	746	466
89	755	472
90	768	477
91	772	482
92	780	487
93	788	493
94	797	498
95	805	509
96	814	503
97	822	514
98	831	519
99	839	524
100	848	530
200	1696	1060
300	2544	1590

M.	33 d.	57 d.
1	8	5
2	17	11
3	25	16
4	34	22
5	42	27
6	50	33
7	59	38
8	67	44
9	76	49
10	84	54
11	92	60
12	101	65
13	109	71
14	117	76
15	126	82
16	134	87
17	143	93
18	151	98
19	159	104
20	168	109
21	176	114
22	185	120
23	193	125
24	201	131
25	210	136
26	218	142
27	227	147
28	235	153
29	243	158
30	252	163
31	260	169
32	269	174
33	277	180
34	285	185

M.	33 d.	57 d.
35	294	191
36	302	196
37	311	202
38	319	207
39	327	212
40	335	218
41	344	223
42	352	229
43	361	234
44	369	240
45	377	245
46	386	251
47	394	256
48	403	262
49	411	267
50	419	272
51	428	278
52	436	283
53	445	288
54	453	294
55	461	300
56	470	305
57	478	310
58	487	316
59	495	321
60	503	327
61	512	332
62	520	338
63	529	343
64	537	348
65	545	354
66	554	355
67	562	365
68	571	370

Min.	33 d.	57 d.
69	579	370
70	587	381
71	596	386
72	604	392
73	612	397
74	621	403
75	629	408
76	637	414
77	646	419
78	654	425
79	663	430
80	671	436
81	679	441
82	688	446
83	696	452
84	705	457
85	713	462
86	721	468
87	730	473
88	738	479
89	747	484
90	755	490
91	763	495
92	772	501
93	780	506
94	789	512
95	797	517
96	805	522
97	814	528
98	822	533
99	831	539
100	839	545
200	1677	1089
300	2516	1634

M.	34 d.	56 d.
1	8	6
2	17	11
3	25	17
4	33	22
5	41	28
6	40	34
7	58	39
8	66	45
9	75	50
10	82	56
11	91	61
12	99	67
13	108	73
14	116	78
15	124	84
16	133	89
17	141	95
18	149	101
19	158	106
20	166	112
21	174	117
22	182	123
23	191	129
24	199	134
25	207	140
26	216	145
27	224	151
28	232	157
29	240	162
30	249	168
31	257	173
32	265	179
33	274	184
34	282	190

M.	34 d.	56 d.
35	190	296
36	298	201
37	307	207
38	315	212
39	323	218
40	332	224
41	340	229
42	348	235
43	356	240
44	365	246
45	373	251
46	381	257
47	390	263
48	398	268
49	406	274
50	414	280
51	423	285
52	431	291
53	439	296
54	448	302
55	456	307
56	464	313
57	473	319
58	481	324
59	489	330
60	497	335
61	506	341
62	514	346
63	522	352
64	530	358
65	539	363
66	547	369
67	555	374
68	564	380

Min.	34 d.	56 d.
69	572	386
70	580	391
71	588	397
72	597	403
73	605	408
74	613	414
75	622	419
76	630	425
77	638	431
78	647	436
79	655	442
80	663	447
81	671	453
82	680	458
83	688	464
84	696	470
85	705	475
86	713	481
87	721	486
88	729	492
89	738	498
90	746	503
91	754	509
92	763	514
93	771	520
94	779	526
95	788	531
96	796	537
97	804	542
98	812	546
99	821	554
100	829	559
200	1658	1118
300	2487	1678

M.	35 d.	55 d.	M.	35 d.	55 d.	Min.	35 d.	55 d.
1	8	6	35	286	201	69	565	396
2	17	11	36	295	206	70	573	402
3	25	17	37	303	212	71	582	407
4	33	23	38	311	218	72	590	413
5	41	29	39	319	224	73	598	419
6	49	34	40	328	229	74	606	425
7	57	40	41	336	235	75	615	430
8	66	46	42	344	241	76	623	436
9	74	52	43	352	246	77	631	442
10	82	57	44	360	252	78	639	448
11	90	63	45	368	258	79	647	453
12	98	69	46	377	264	80	655	459
13	106	75	47	385	270	81	664	465
14	115	80	48	393	275	82	672	475
15	123	86	49	401	281	83	680	470
16	131	92	50	415	280	84	688	482
17	139	98	51	418	292	85	696	488
18	147	103	52	426	298	86	705	493
19	156	109	53	434	304	87	713	499
20	164	115	54	442	310	88	721	505
21	172	120	55	451	315	89	729	511
22	180	126	56	459	321	90	737	516
23	188	132	57	467	327	91	746	522
24	196	138	58	475	333	92	754	528
25	205	143	59	483	338	93	762	534
26	213	149	60	491	344	94	770	539
27	221	155	61	500	350	95	778	545
28	229	161	62	508	356	96	786	551
29	237	166	63	516	361	97	795	556
30	246	172	64	524	367	98	803	562
31	254	178	65	533	373	99	811	468
32	262	184	66	541	379	100	819	474
33	270	189	67	549	384	200	1638	1174
34	278	195	68	557	390	300	2458	1721

M.	36d.	54d.
1	8	6
2	16	12
3	24	18
4	32	23
5	40	29
6	48	35
7	56	41
8	64	47
9	72	53
10	81	59
11	89	65
12	97	70
13	105	76
14	113	82
15	121	88
16	139	94
17	138	100
18	146	106
19	154	112
20	162	118
21	170	123
22	178	129
23	186	135
24	194	141
25	202	147
26	210	153
27	218	159
28	226	164
29	235	170
30	243	176
31	251	182
32	259	188
33	267	194
34	275	200

M.	36d.	54d.
35	283	206
36	291	211
37	299	217
38	307	223
39	315	239
40	324	225
41	332	241
42	340	247
43	348	253
44	356	258
45	364	264
46	372	270
47	480	276
48	488	282
49	496	288
50	404	294
51	413	300
52	421	306
53	429	311
54	437	317
55	445	323
56	453	329
57	461	335
58	469	341
59	477	347
60	485	353
61	493	358
62	502	364
63	510	370
64	518	376
65	526	382
66	534	388
67	542	394
68	550	400

Min.	36d.	54d.
69	558	406
70	566	411
71	574	417
72	582	423
73	590	439
74	599	435
75	607	441
76	615	447
77	623	453
78	631	458
79	939	464
80	647	470
81	655	476
82	663	482
83	671	488
84	680	494
85	688	500
86	696	506
87	704	511
88	712	517
89	720	523
90	728	529
91	736	535
92	744	541
93	752	547
94	760	553
95	768	558
96	777	564
97	785	570
98	793	576
99	801	582
100	809	588
200	1618	1176
300	2426	1763

M.	37 d.	53 d.
1	8	6
2	16	12
3	24	18
4	32	24
5	40	30
6	48	36
7	56	42
8	64	48
9	72	54
10	80	60
11	88	66
12	96	72
13	104	78
14	112	84
15	120	90
16	128	96
17	136	102
18	144	108
19	152	114
20	160	120
21	168	126
22	176	132
23	184	138
24	192	144
25	200	150
26	208	156
27	216	162
28	224	168
29	232	174
30	240	180
31	248	189
32	256	192
33	264	198
34	271	204

M.	37 d.	53 d.
35	279	210
36	287	216
37	295	222
38	303	228
39	311	234
40	319	241
41	327	247
42	335	253
43	343	259
44	351	265
45	359	271
46	367	277
47	375	283
48	383	289
49	391	295
50	399	301
51	407	307
52	415	313
53	423	319
54	431	325
55	439	331
56	447	337
57	455	343
58	463	349
59	471	355
60	499	361
61	487	367
62	595	373
63	503	379
64	511	385
65	519	391
66	527	397
67	535	403
68	543	409

Min.	37 d.	53 d.
69	551	415
70	559	421
71	567	427
72	575	433
73	583	439
74	591	445
75	599	451
76	607	457
77	615	463
78	623	469
79	631	475
80	639	481
81	647	487
82	655	493
83	663	500
84	671	506
85	679	512
86	687	518
87	699	524
88	703	530
89	711	536
90	719	542
91	727	548
92	735	554
93	743	560
94	751	566
95	759	572
96	767	578
97	775	584
98	783	590
99	791	596
100	799	602
200	1597	1204
300	2396	1805

M.	38d.	52d.	M.	38d.	52d.	Min.	38 d.	52 d.
1	8	6	35	276	216	69	544	425
2	16	12	36	284	222	70	552	431
3	24	18	37	292	228	71	559	437
4	31	25	38	299	234	72	567	443
5	39	31	39	307	240	73	575	450
6	47	37	40	315	246	74	583	456
7	55	43	41	323	252	75	591	462
8	63	49	42	331	259	76	599	468
9	71	55	43	339	265	77	607	474
10	79	62	44	347	271	78	615	480
11	87	68	45	355	277	79	622	486
12	95	74	46	362	283	80	630	493
13	102	80	47	370	289	81	638	499
14	110	86	48	378	296	82	646	505
15	118	92	49	386	302	83	654	511
16	126	99	50	394	308	84	662	517
17	134	105	51	402	310	85	670	523
18	142	111	52	410	324	86	678	530
19	150	117	53	418	326	87	686	536
20	158	123	54	426	332	88	693	542
21	166	129	55	433	339	89	701	548
22	173	136	56	441	345	90	709	554
23	181	142	57	449	351	91	717	560
24	189	148	58	457	357	92	725	566
25	197	154	59	465	363	93	733	573
26	205	160	60	473	369	94	741	579
27	213	169	61	481	376	95	749	585
28	221	172	62	489	382	96	756	591
29	229	179	63	496	388	97	764	597
30	236	185	64	504	394	98	772	602
31	244	191	65	512	400	99	780	610
32	252	197	66	520	406	100	788	616
33	260	203	67	528	412	200	1576	1231
34	268	209	68	536	419	300	2364	1847

M.	39 d.	51 d.	M.	39 d.	51 d.	Min.	39 d.	51 d.
1	8	6	35	272	220	69	536	434
2	16	13	36	280	226	70	544	440
3	23	19	37	287	232	71	552	447
4	31	25	38	295	239	72	559	453
5	39	31	39	303	245	73	567	459
6	47	38	40	311	252	74	575	466
7	54	44	41	318	258	75	583	472
8	62	50	42	326	264	76	591	478
9	70	57	43	334	271	77	598	485
10	78	63	44	342	277	78	606	491
11	85	69	45	350	283	79	614	497
12	93	75	46	357	289	80	622	503
13	101	82	47	365	296	81	629	510
14	109	88	48	373	302	82	637	516
15	116	94	49	381	308	83	645	522
16	124	101	50	388	315	84	653	529
17	132	107	51	396	321	85	661	535
18	140	113	52	404	327	86	668	541
19	148	119	53	412	334	87	676	547
20	155	126	54	419	340	88	684	554
21	163	132	55	427	346	89	692	560
22	171	138	56	435	352	90	699	566
23	179	145	57	443	359	91	707	573
24	186	151	58	451	365	92	715	579
25	194	157	59	458	371	93	723	585
26	202	164	60	466	378	94	731	591
27	210	170	61	474	384	95	738	598
28	217	176	62	482	390	96	746	604
29	225	182	63	489	399	97	754	610
30	233	189	64	497	403	98	762	617
31	241	195	65	505	409	99	769	623
32	249	201	66	513	415	100	777	629
33	256	208	67	521	422	200	1554	1259
34	264	214	68	528	428	300	2331	1888

M.	40 d.	50 d.
1	8	6
2	15	13
3	23	19
4	31	26
5	38	32
6	46	38
7	54	45
8	61	51
9	69	58
10	77	64
11	84	71
12	92	77
13	100	83
14	107	90
15	115	96
16	123	103
17	130	109
18	138	116
19	146	122
20	153	129
21	161	135
22	169	141
23	176	148
24	184	154
25	192	161
26	199	167
27	207	173
28	214	180
29	222	186
30	230	193
31	237	199
32	245	206
33	253	212
34	260	219

M.	40 d.	50 d.
35	268	225
36	276	231
37	283	238
38	291	244
39	299	251
40	306	257
41	314	263
42	322	270
43	329	276
44	338	283
45	345	289
46	352	296
47	360	302
48	368	309
49	375	315
50	383	321
51	391	328
52	398	334
53	406	341
54	414	347
55	421	353
56	429	360
57	437	366
58	444	373
59	452	379
60	460	386
61	467	392
62	475	399
63	483	405
64	490	411
65	498	418
66	506	424
67	513	431
68	521	437

Min.	40 d.	50 d.
69	529	443
70	536	450
71	544	456
72	552	463
73	559	469
74	567	476
75	574	482
76	582	485
77	590	495
78	597	501
79	605	508
80	613	514
81	620	521
82	628	527
83	636	533
84	643	540
85	651	546
86	659	553
87	666	559
88	674	566
89	682	572
90	689	579
91	697	585
92	705	591
93	712	598
94	720	604
95	727	611
96	735	617
97	743	623
98	751	630
99	758	636
100	766	643
200	1532	1286
300	2298	1928

M.	41 d.	49 d.
1	8	7
2	15	13
3	23	20
4	30	26
5	38	33
6	45	39
7	53	46
8	60	52
9	68	59
10	75	66
11	83	72
12	91	79
13	98	85
14	106	92
15	113	98
16	121	105
17	128	112
18	136	118
19	143	125
20	151	131
21	159	138
22	166	144
23	174	151
24	181	157
25	189	164
26	196	171
27	204	177
28	211	184
29	219	190
30	226	197
31	234	203
32	241	210
33	249	216
34	257	223

M.	41 d.	49 d.
35	264	229
36	272	236
37	279	243
38	287	249
39	294	256
40	302	262
41	309	266
42	317	275
43	324	282
44	330	389
45	339	395
46	347	302
47	354	308
48	362	315
49	369	321
50	377	328
51	385	334
52	392	341
53	400	348
54	407	354
55	415	361
56	422	367
57	430	374
58	438	380
59	445	387
60	453	394
61	460	400
62	468	407
63	475	413
64	483	420
65	490	426
66	498	433
67	506	439
68	513	446

Min.	41 d.	49 d.
69	521	452
70	528	459
71	536	466
72	543	472
73	551	478
74	558	485
75	566	492
76	574	498
77	581	505
78	589	512
79	596	518
80	604	525
81	611	531
82	619	538
83	626	544
84	634	551
85	641	557
86	649	564
87	656	571
88	664	577
89	671	584
90	679	590
91	687	597
92	694	603
93	702	610
94	709	616
95	717	623
96	724	629
97	732	636
98	739	643
99	747	649
100	755	656
200	1509	1312
300	2264	1968

M.	42 d.	48 d.
1	7	7
2	15	13
3	22	20
4	30	27
5	37	33
6	44	40
7	52	47
8	59	53
9	67	60
10	74	67
11	82	73
12	89	80
13	97	87
14	104	93
15	111	100
16	119	107
17	126	113
18	134	120
19	141	127
20	149	134
21	156	140
22	163	147
23	171	154
24	178	160
25	186	167
26	193	174
27	201	180
28	208	187
29	215	194
30	223	201
31	230	207
32	238	214
33	245	221
34	253	227
35	260	234
36	267	241
37	275	247
38	282	254
39	290	261
40	297	268
41	304	274
42	312	281
43	319	287
44	327	294
45	334	301
46	342	308
47	349	314
48	357	321
49	364	328
50	372	335
51	379	341
52	386	348
53	394	354
54	401	361
55	409	368
56	416	375
57	423	381
58	431	388
59	438	394
60	446	401
61	453	408
62	461	415
63	468	421
64	475	428
65	483	435
66	490	442
67	498	448
68	505	455

Min.	42 d.	48 d.
69	513	462
70	520	468
71	527	475
72	535	482
73	542	488
74	550	495
75	557	502
76	564	509
77	572	515
78	579	522
79	587	529
80	594	535
81	602	542
82	609	549
83	617	555
84	624	562
85	632	569
86	639	575
87	647	582
88	654	589
89	661	595
90	669	602
91	676	609
92	684	615
93	691	622
94	699	629
95	706	635
96	713	642
97	721	649
98	728	655
99	736	662
100	743	669
200	1486	1338
300	2229	2007

M.	43 d.	47 d.	M.	43 d.	47 d.	Min.	43 d.	47 d.
1	7	7	35	256	239	69	505	470
2	15	14	36	263	245	70	512	477
3	22	20	37	270	252	71	519	484
4	29	27	38	278	256	72	526	491
5	36	34	39	285	266	73	534	498
6	44	41	40	292	273	74	541	505
7	51	48	41	300	280	75	548	511
8	58	54	42	307	286	76	556	518
9	66	61	43	314	293	77	563	525
10	73	68	44	322	300	78	570	532
11	80	75	45	329	307	79	578	539
12	88	82	46	336	314	80	585	546
13	95	89	47	344	320	81	592	552
14	102	95	48	351	327	82	600	659
15	110	102	49	358	334	83	607	666
16	117	109	50	366	341	84	614	673
17	124	116	51	373	348	85	623	680
18	132	123	52	380	355	86	629	687
19	139	130	53	388	361	87	636	693
20	146	136	54	395	368	88	643	600
21	153	143	55	402	375	89	651	607
22	161	150	56	409	382	90	658	614
23	168	157	57	417	389	91	665	621
24	175	164	58	424	395	92	673	637
25	183	170	59	431	402	93	680	634
26	190	177	60	439	409	94	687	641
27	197	184	61	446	416	95	695	648
28	205	191	62	453	423	96	702	655
29	212	198	63	461	430	97	703	661
30	219	205	64	468	436	98	717	668
31	227	211	65	475	443	99	724	675
32	234	218	66	483	450	100	731	682
33	241	225	67	490	457	200	1463	1364
34	248	232	68	497	464	300	2194	2046

M.	44 d.	46 d.
1	7	7
2	14	14
3	22	21
4	29	28
5	36	35
6	43	42
7	50	49
8	58	56
9	65	62
10	72	69
11	79	76
12	86	83
13	93	90
14	101	97
15	108	104
16	115	111
17	122	118
18	129	125
19	137	132
20	144	139
21	151	146
22	158	153
23	165	160
24	173	167
25	180	174
26	187	181
27	194	188
28	201	195
29	209	201
30	216	208
31	223	215
32	230	222
33	237	229
34	245	236

M.	44 d.	46 d.
35	252	243
36	259	250
37	266	257
38	273	264
39	280	271
40	288	278
41	295	285
42	302	292
43	309	299
44	316	306
45	324	313
46	331	320
47	338	327
48	345	334
49	352	340
50	360	347
51	367	354
52	374	361
53	381	368
54	388	375
55	396	382
56	403	389
57	410	396
58	417	403
59	424	410
60	432	417
61	439	424
62	446	431
63	453	438
64	460	445
65	468	452
66	475	458
67	482	465
68	489	472

Min.	44 d.	46 d.
69	496	479
70	503	486
71	511	493
72	518	500
73	525	507
74	532	514
75	539	521
76	547	528
77	554	535
78	561	542
79	568	549
80	575	556
81	583	563
82	590	570
83	597	577
84	604	584
85	611	590
86	619	597
87	626	604
88	633	611
89	640	618
90	647	625
91	655	632
92	662	639
93	669	646
94	676	653
95	683	660
96	690	667
97	698	674
98	705	681
99	712	688
100	719	695
200	1439	1389
300	2158	2084

M.	45 d.	45 d.
1	7	7
2	14	14
3	21	21
4	28	28
5	35	35
6	42	42
7	49	49
8	56	56
9	64	64
10	71	71
11	78	78
12	85	85
13	92	92
14	99	99
15	106	106
16	113	113
17	120	123
18	127	127
19	134	134
20	141	141
21	148	148
22	155	155
23	163	163
24	170	170
25	177	177
26	184	184
27	191	191
28	198	198
29	205	205
30	212	212
31	219	219
32	226	226
33	233	233
34	240	240

M.	45 d.	45 d.
35	247	247
36	254	254
37	261	261
38	268	268
39	275	275
40	283	283
41	290	290
42	297	297
43	304	304
44	311	311
45	318	318
46	325	325
47	332	332
48	339	339
49	346	346
50	353	353
51	360	360
52	367	367
53	375	375
54	382	382
55	389	389
56	396	396
57	403	403
58	410	410
59	417	417
60	424	424
61	431	431
62	438	438
63	445	445
64	452	452
65	459	459
66	466	460
67	474	474
68	481	481

Min.	45 d.	45 d.
69	488	488
70	495	495
71	502	502
72	509	509
73	516	516
74	523	523
75	530	530
76	537	537
77	544	544
78	551	551
79	558	558
80	566	566
81	573	573
82	580	580
83	587	587
84	594	594
85	601	601
86	608	608
87	615	615
88	622	622
89	629	629
90	636	636
91	643	643
92	650	650
93	657	657
94	665	665
95	672	672
96	678	678
97	686	686
98	693	693
99	700	700
100	707	707
200	1414	1414
300	2121	2121

Now for the form of ſetting down a Reckoning, although he which is accuſtomed to keep it in this manner, may haply by uſe and practice diſcern how to order it in a better way then I can preſently preſcribe or think upon, becauſe he hath occaſion often to conſider it in every particular: yet in the mean time I conceive it will be fit to have a Book in *Folio*, that is, two Leaves to a ſheet of Paper, and to keep the left ſide of your Book void, that you may write therein all ſuch Occurrents as you ſhall think requiſite. As namely, the Winds, and the Points of the *Compaſs*, upon which your Ship lies, and what allowance you make for *Lee-ward* way when you Sail by a Wind, the number of Glaſſes or Hours, and how many Knots or Miles in each hour, alſo the Latitudes which you find by Obſervation of the Meridian-altitude of the Stars, and what elſe you ſhall think remarkable. But before all this, the title of the voyage in theſe or the like words.

The Journal of our Voyage intended by Gods aſſiſtance from S. I. *in the Latitude of* 32 deg. 25 min. *to the Coaſt of* England, *&c.*

The right hand Pages, or the right ſide of your Book throughout, may by Lines be divided into 12 Columns, as in the Example following doth appear. In the firſt Column may be expreſſed the Day, in the ſecond the Month; or at leaſt once in the top of the Page; likewiſe in the ſame ſecond Column, being large enough, may be ſet down the Latitudes which you find by the Meridian-altitudes of the Sun at ſuch times as you make obſervation. In the 3 Column the Courſe (the *Lee-ward* way, if there be any Leeing allowed.) In the 4 the variation of the Needle. In the 5 (having made allowance for the variation) ſet down the Angle of your Rumb with the Meridian. In the 6 Column ſet down the diſtance in Miles run upon that Rumb. In the 7, 8, 9, and 10 Columns the Northing or Southing, Eaſting or Weſting, thereto anſwering, as you ſhall find it by your Table. In the 11 your Latitudes by dead reckoning. And laſtly, in the 12 Column you may at ſuch times as you think fitteſt, ſet down your *Longitude* from the place from which you firſt departed, or the difference of Longitude from place to place.

da.	Lat. by observation.	courte	Variation.	Deg. fro the mirid	di. in miles	North	South	East	West	Lat. by dead R	Longitude.
					miles					de.	
20	February	N E by E	8deg. west	ne 48d	78	522		579		33.17	
21	Latitude 34 d. 25'	N E by E	8deg. west	ne 48d	100	669		743		34.24	
21	34 d. 25'			Summe is		1191		1322		34.24	02.38
22		e n e ⅓ poi.	8deg. west	ne 54d	100	588		809		35.56	
					56	329		453			
23	Latitude 37 d. 46'	e n e ⅓ no.	8deg. west	ne 54d	100	588		809		37.40	
					78	458		631			
24	Latitude 39 d. 36'	e n e ⅓ no.	8deg. west	ne 54d	100	588		809		39.28	
					84	494		679			
				Summe is		3045		4190			
		The correction by obser. is				80		1110		08	
24	39.36					31251		43001		39.36	11.36
25	February	e n e	8deg. west	ne 59½	100	507		861		41.05	
					76	385		655			
26		e n e	8deg. west	ne 59½	100	507		861		42.37	
					80	412		586			
27	Latitude 43 d. 55	e n e	7½deg west	ne 60d	100	500		866		44.09	
					84	420		728			
				Summe is		2731		14657			
				Correction				1140	1245	14	
27	L. 43.55					2591		14412		43.55	21.28
28	February	e n e ½ e	6deg. west	ne 67d	100	391		921		44.54	
					51	199		469			
29		e n e ½ e	5deg. west	ne 68d	100	375		927		45.02	
					81	304		751			
1	March	e n e ½ e	4deg. west	ne 69d	100	358		934		47.02	
					66	237		616			
2	La. 48.4.	e n e ½ e	2deg. west	ne 71d	100	326		946		48.00	
					78	254		737			
2	La. 48.4.			Summe is		2444		16301		48.00	36.3.8

da	Lat. by observation.	court.	Variation.	Dep. fr the Mer.	di. in miles	North.	South.	East	West	Lat by dead R	Longitude.
3	March	e n e ½ e	0 de. west	n e 73 d	100 52	292 152		956 497		48.44	
4		e n e ½ e	2 de East	n e 75 d	100 68	259 176		966 657		49.28	
5	Latitude 49.58 d.	e n e ½ e	3 de. East	n e 76 d	98	237		951		49.52	
5	la. 49.58			Summe is		1116		4027		49.52	46.52
5	8 Hours	n by e ⅓ e	4 de. East	n e 21 d	18	168		64		50.09	
6		South by e	4 de East	s e 7 d.	34		337	41		49.35	
6	16 Hours	n by east	4 de. East	n e 15 d	36	348		93		50.10	
7		s e by east	4 de. East	s e 52 d	29		123	158		49.58	
8	Latitude 50 d. 4'	East	4 de. East	s e 86 d	96		67	958		49.51	
	The current setting by estima.	East nort. east.		n e 67½	60	230		554		50.14	
				Summe is		319		1868			
				Correction			100			10'	
8	la. 50 d. 4					119		1868		50 04	51 43
9		east ½ po. n	6 de East	s e 89½ d	70		60	700		49.58	
10		east ½ po. n	6 de East	s e 89½ d	52		41	520		49.54	
10	March	h		Summe is		1101		1220		49.54	54.53
	Here the Lizard bears	N by E			13						

For an Example, we may frame a Reckoning between the two places before-mentioned, namely from *Summers-Iſlands* to the *Lizard*, whoſe diſtance in their Rumb we have before ſuppoſed to be 3299 Miles, as ſome Charts make it, and conſequently their difference of Longitude 70 *deg.* I would not be underſtood as if I affirmed it to be ſo much, for I ſuppoſe it is leſs. I was there indeed about 20 years paſt, and Surveyed it, and than kept a Reckoning both outwards and homewards, but I have loſt thoſe Reckonings long ſince, and have forgotten what they were, and in this caſe it matters not; for whether the ſuppoſition be near the truth or not, it ſerves ſufficiently to exemplifie the Rule, that being the end for which it is uſed. But if their diſtance be 3299 ſuch Miles as contain only 1000 Paces in a Mile, the ſame being reckoned in ſuch Miles, as we have before-mentioned, namely, in ſuch whereof 60 make a *degree* of a great Circle, which as we find contain 6120 Feet in a Mile, their diſtance will be little more than 2695 Miles, and conſequently, the difference of Longitude little more than 55½ *degrees.*

Let us therefore ſuppoſe the difference of Longitude between thoſe two places to be 55 *degrees*, and their Latitudes to be the ſame as before, namely of the one 32 *deg.* 25 *min.* and of the other 50 *degrees.* And let the Courſes, Diſtances, and other Obſervations from *Summers-Iſlands* to the *Lizard* to be ſuch as before is ſhewed.

The firſt entrance in this Journal, (which is the 20 Day of *February*) is thus to be underſtood; namely, that from the time of ſetting Sail (which we ſuppoſe to be the 19 of *February*) till the 20 Day at Noon, the Ship lies away, and makes her way good upon the Northeaſt and Eaſt Point of the Compaſs; but the variation being 8 *degrees* to the Weſtwards (as in the fourth Column appears) the Rumb upon which ſhe hath run is from the North to the Eaſtwards only 48 *degr.* as is expreſſed in the 5 Column (it is indeed 48¼ *deg.* but the ¼ *deg.* we omit, as for the other circumſtances not to be regarded) upon this Rumb ſhe runs 78 Miles, as in the 6 Column appears, and anſwerable thereto I find in the Table before-going, the Northing to be 52$\frac{2}{10}$ miles,

and

and the Eaſting 57 $\frac{2}{10}$, as here in the ſeventh and ninth Column is expreſſed by theſe numbers 522 and 579 (for the firſt Figure towards the right hand ſignifyeth the tenth parts of a Mile, the reſt Miles.) Hence then the Northing being 52 Miles, if that be added to the Latitude from which it is reckoned, namely, 32 *deg.* 25 *min.* it makes the Latitude here to be 33 *deg.* 17 *min.* as in the 11 Column appears. In like ſort, the ſecond entrance being the 21 of *February*, ſheweth that from the 20 Day at Noon to the 21, ſhe made her way good upon Northeaſt and by Eaſt Point of the Compaſs, but the Variation being 8 *degrees* Weſterly, the Angle of the Rumb with the true Meridian was from the North to the Eaſtwards 48 *degrees*, and ſo Sailing 100 miles, the Northing is 69 $\frac{9}{10}$ miles, and the Eaſting 74 $\frac{3}{10}$ miles, ſo that the Latitude now is 34 *degr.* 24 *min.* and the like is to be underſtood of all the reſt.

Touching the Longitude expreſſed in the laſt Column, although a reckoning may be kept and ſet down without it, yet it is of very good uſe; and how to convert the Eaſting or Weſting (that is, the miles expreſſed in the Eaſt and Weſt Columns of your Journal) into *degr.* and *min.* of Longitude; we will ſhew afterwards, as alſo how you may eaſily correct your Courſe, and give the true Courſe or Rumb, allowing the Variation.

But thus to proceed with this Journal, obſerving the Meridian-altitude of the Sun upon the 23 and 24 *February*, I find that my Latitude upon the 24, is 39 *deg.* 36 *min.* whereas by dead reckoning it is but 39 *deg.* 28 *min.* ſo the difference is 8 more Northerly: but being well aſſured of the Latitude found by Obſervation, I correct the dead reckoning thereby, which may be done by the Rule of Proportion, ſaying;

As the Sum of the North Column 3125		*Co. ar.* 6.50515
To the Sum of the Eaſt Column,	4300	3.63347
So the foreſaid increaſe Northerly	80	1.90309
To the increaſe Eaſterly	110	2.04171

That is, 11 miles: for the firſt place towards right hand is only for the tenth parts of a mile.

The

The ſame may alſo ſufficiently be found without the Rule of Proportion, by the foregoing Table, only for looking there under the *degree* upon which I have Sailed, namely, under 54 *deg.* for 8 miles or 80 tenths of a mile, though I find not the ſame exactly, yet I find one which is near it, namely 82, and againſt it in the next collateral Column 113, which is 11 $\frac{3}{10}$ miles (being too much by $\frac{3}{10}$ of a mile, becauſe the other is too much by $\frac{2}{10}$) I add therefore in the North Column of the Journal 8 miles, and the Eaſt Column 11 miles; and ſo whereas by dead reckoning, the Northing was but 304 $\frac{1}{10}$ miles, and Eaſting 194 miles; now having corrected it by obſervation, the Northing is 312 $\frac{1}{10}$ miles, and Eaſting 430 miles.

In like ſort upon the 27*th* day, I ſhould by dead Reckoning be in the Latitude of 44 *deg.* 09 *min.* but by a clear and good obſervation I find my ſelf in the Latitude of 43 *deg.* 55 *min.* that is, not ſo much Northerly by 14 *min.* therefore to correct it I put in the South column 14 miles, or 140 tenths, and ſeeing my courſe was between the North and the Eaſt, and that I find my ſelf to be leſs to the Northwards, that is more to the Southwards than my reckoning; therefore in probability I am alſo leſs to the Eaſtwards, that is, more to the Weſtwards than my Reckoning; But to find how much, I look in the foregoing Table for the *degrees* upon which I have Sailed, being from the North part of the Meridian to the Eaſtwards 60 *deg.* and under 60 *deg.* I look for 14 miles, or 140 tenths, and againſt it in the Column adjoining I find 243, which I ſet down in my Journal in the Weſt Column, and ſo ſubſtracting the firſt from the North Column, the other from the Eaſt: I find that whereas by dead Reckoning I ſhould be to the Northwards 273 $\frac{1}{10}$ miles, and to the Eaſtwards 465 $\frac{7}{10}$. Now having corrected it by Obſervation, I find that from the 24*th* day till this time I have run more Northerly than I was by 259 $\frac{1}{10}$ miles, and more Eaſterly by 441 $\frac{2}{10}$ miles.

But if your Courſe be near the Eaſt or Weſt, it may ſuffice to correct it in Latitude only, as in the Example of the 8 of *March* appears; for in that caſe you cannot correct Longitude, but from ſome further ground.

If

If there be any Current, you may note it as is done in that Example following the 8*th* of *March*.

Now if you would ſet down this Reckoning upon the Plain or common *Sea-Chart*: Firſt, if you deſire to expreſs every days account, you may begin for the 20 of *February*, and make a prick in your Plot that may be from the place from which you ſet Sail to the Northwards $52\frac{2}{10}$ miles, and to the Eaſtwards $57\frac{2}{10}$; and ſo will this Point be diſtant from the place of your ſetting ſail 78 miles Northeaſt, and almoſt a quarter of a Point Eaſterly: then for the 21 day you may make another Prick, which may be from the form to the Northwards $66\frac{8}{10}$ miles, and to the Eaſtwards $74\frac{3}{10}$ miles, and ſo you may proceed with the reſt. And thus you ſhall have a Prick on the Plot for every day more exactly ſet down, then could be done after the ordinary way by Courſe and Diſtance, or Courſe and Latitude, eſpecially becauſe in lining the Plot, there are not, nor cannot conveniently be drawn any more than the 32 Points of the Compaſs, *viz.* not half Points, quarters, or ſingle *degrees*.

But if you deſire not to ſet down every days reckoning (which is not neceſſary to be done) you may ſet down every of the ſums, as they are corrected by obſervation after the ſelf-ſame manner.

Or you may add together all thoſe ſums, and ſo the ſum total of the North Column will be 1409 Miles, and of the Eaſt Column 2345 Miles, therefore in the Meridian of the place from which you depart, you may ſet down to the N. wards of that place 1049 Miles, which will fall in the Latitude of 49 *deg.* 54 *min.* almoſt, and from thence in that Parallel ſet down directly to the Eaſtwards 2345 Miles, and there make a Prick for the place where the Ship then is the tenth of *March*, and ſo is all this Reckoning ſet down at once.

If you keep Reckoning according to *Mercator*, it will be requiſite ſometimes to ſum up your Reckonings paſt, namely, ſo often as you make any notable alteration in your Courſe, and ſo this Reckoning or any other may be ſet down almoſt as eaſily on *Mercator*'s *Chart*, the difference is, that there you muſt often alter your *Scale*, becauſe the *deg.* of Latitude on this *Chart* are not equal,

equal, but grow greater and greater towards the Poles. Now then the diſtance of two places is to be meaſured by that part of the Meridian, which is intercepted between the Latitudes of thoſe two places; Or if both places lie in one and the ſame Latitude, their diſtance is meaſured by a *degree* or other leſs quantity, taken about that Latitude; namely, half above, and half beneath.

Wherefore if you would make a Prick or Traverſe-point in *Mercators-Chart*, anſwering to your reckoning for the firſt day, namely, until the 20 of *February* at Noon; it appears by your Journal that Prick muſt be to the Northwards of the place from which you departed $52\frac{2}{10}$ miles, and to the Eaſtwards $57\frac{2}{10}$ miles.

Now inſtead of the North or South Columns, you may more conveniently uſe the laſt Column but one, ſhewing in what Latitude every account doth fall; and ſo it appears, that the Prick for the 20 of *February* muſt be in the Latitude of 33 *degr.* 17 *min.* Therefore in the Meridian of the *Summers-Iſlands* from which you departed, make a Prick in the Latitude of 33 *deg.* 17 *min.* and from that Prick ſet down to the Eaſtwards in the ſame Latitude $57\frac{2}{10}$ miles, and where it ends is the Traverſe-point anſwering to the 20 of *February*: the like may be done for the 21 Day, and ſo for all the reſt. This 58 miles may be taken in the Meridian from the Latitude of 32 *degr.* 22 *min.* to the Latitude of 33 *deg.* 20 *min.* or otherwiſe you may take the half of it, which is 29 miles about the middle between both Latitudes and double it.

But it is ſufficient to ſet down the ſums of every two or three days accounts, or ſo often as there is any notable Difference in your Courſe. Thus if you would make a Prick in the *Chart*, anſwering to the 21 of *February*, being the firſt ſum; I ſee by the Journal, that it muſt be in the Latitude of 34 *deg.* 24 *min.* and to the Eaſtwards of the place from which I departed $132\frac{2}{10}$ miles. Therefore in the Meridian of the place from whence I departed, I make a Prick in the Latitude 34 *degr.* 24 *min.* and from that Prick I ſet in the ſame Latitude to the Eaſtwards $132\frac{2}{10}$ miles, and where it ends if the Traverſe-point anſwering to the 21 of *February*, being the firſt ſum. This 132 miles may be taken in the Meridian within, or a little without the two Latitudes, as before, namely, from 32 *deg.* 20 *min.* to 34 *deg.* 32 *min.* In

In like ſort, if you would make a Prick for the ſecond ſum, being the 24 of *February*, it there appears that it muſt be in the Latitude of 39 *deg.* 36 *min.* and to the Eaſtwards of the Traverſe-Point laſt before made 430 miles; therefore in the Meridian of that Traverſe-point I make a Prick in the Latitude of 39 *deg.* 36 *min.* and from that Prick I ſet to the Eaſtwards in the ſame Latitude 430 miles, and where that ends is the Traverſe-Point anſwering to the 24 Day, and the like is to be underſtood of all the reſt.

Now this 430 miles may be taken ſeveral ways; for firſt, If I take one *Degree* about the middle of that part of the Meridian, which is intercepted between the Latitudes of the two places (as from 36 *deg.* 30 *min.* to 37 *deg.* 30 *min.*) and that *degree* ſeven times taken, is 420 miles, then about the middle, namely, 37 *deg.* I take 10 *min.* more, and ſo I have 430 miles.

In like manner, you may take two *deg.* or 120 miles to meaſure it thereby, which may be taken from 36 *degrees* to 38 *deg.* and the reſidue about 37 *degrees*, as before, *&c.*

Or you may take the half of 430 miles, namely, 215 miles, which is 3 *deg.* 35 *min.* which muſt be taken as before, about the middle of that part of the Meridian which is intercepted between the two Latitudes, and that doubled is 430 miles to be ſet to the Eaſtwards, as before.

And thus may this or any other Reckoning be ſet down without knowledge of the Longitudes, but more aptly and exactly by ſome Longitudes known, for then ſhall you have in the two laſt Columns, the ſubſtance and principal ſcope of your Reckoning; namely, the Latitudes and Longitudes of all places, as you Sail, which may more eaſily and exactly be expreſs'd upon this *Chart*, then the Eaſterly or Weſterly diſtances; Therefore how this alſo may be done, we will ſhew, but firſt ſomething touching the *Compaſs*, and the Variation thereof, which ought not to be neglected in a Reckoning.

CHAP. X.

Of the Variation of the Compaſs, and how to rectifie a Courſe by the Variation known.

AMongſt all the myſteries which God hath of late years diſcovered to the World for the furtherance of *Navigation*, there is none more neceſſary, nor yet more admirable than that property of the *Needle* touched with the Load-ſtone, whereby in the vaſt Ocean where all Land-marks fail, yea even in the darkeſt nights and cloſeſt weather, when neither Sun nor Stars are to be ſeen, the Mariner (as it were by a Meſſenger ſent from Heaven) is taught which way to direct his Ship; yea, as it were accompanied with a guide towards his deſired Port.

For the *Needle* touched, beſides other ſtrange properties, hath this, to point out in all quarters of the World, the North and South parts of the Horizon, and ſo having a Card thereto fitted with Rumbs and Degrees, it ſheweth all Points of the Cmpaſs, and Degrees of the Horizon.

Yet very ſeldom exactly of it ſelf, without ſome further art and induſtry of him that uſeth it; for though in ſome places it ſwerves not, yet in moſt parts of the World the North and South Points of the *Needle* have ſome Variation from the true North & South Points of the Horizon to the Eaſtwards or Weſtwards, which how to diſcover in kind and quantity, we have ſhewed heretofore.

It may be thought, (and ſome men otherwiſe learned before this property was fully diſcovered, have ſaid) that this ſhould be ſome blemiſh and imperfection in a Stone ſo precious; but it is ſo far from being an imperfection, that it makes it ſo much the more precious; Yet (as I have ſaid) not without the induſtry of him that uſeth it. He that is negligent or unskilful to obſerve it, eſpecially in long Voyages and Various Courſes, may be led into many dangers by it, becauſe he frames not his mind to the Rule,

but

but the Rule to his mind, imagining it to be what it is not: and hence I ſuppoſe, ſprang that Cuſtom of placing the *Needle* or *Wyars* a Point or half Point to the Eaſtwards of the North Point of the Card, thinking by this means to ſhun the labour of obſerving the Variation, which indeed they might, if the Variation were the ſame in all places, and at all times; but becauſe it it not, this doth often increaſe the errour.

But he that diligently obſerves the Variation, finds (as I ſay) no prejudice in it, only it requires daily, or once in two or three days half an hours work; and this labour it doth abundantly recompence; for by this means he knows at the preſent how to direct his Courſe, and for the future, by thoſe notes which he keeps of the Variations and Latitudes by him obſerved, he knows (coming that way again) when he draws near any of thoſe places where ſuch Obſervations were made, and ſo falls the more certainly with any place intended.

There is further diſcovered of late a motion or alteration in the Variation of the *Needle*, and this is ſcarce yet certainly diſcovered. But comparing the Variations which were obſerved about 50 years paſt, with the preſent Variations: It appears they are leſſer Eaſterly, and more Weſterly by 6 or 7 *degrees*, then they were at that time. For whereas the Variation hath formerly been obſerved near *London* to be $11\frac{1}{4}$ *Deg.* to the Eaſtwards, it doth now ſcarce exceed 4 *Degrees*. And there is the like alteration (as I have heard by ſome Mariners) in other parts of the world; which we now leave to the further diſcovery of time and induſtry, and come to ſhew how to rectifie a Courſe by the Variation known.

The Point of the Compaſs upon which you Sail, and the Variation of the Needle *known, to find the Rumb or Degree upon which the Ship hath made her way.*

IT is beſt that the *Needle* or *Wyars* be placed directly under the *Flower de luce*, or North and South Points of the *Card*, and ſo in the Rules following we preſuppoſe them to be. Now then it is to be underſtood, that the *Needle* having Variation

(as for the moſt part it hath) the Ship doth not make her way upon that Rumb or Point of the Compaſs, which ſhe ſeems to ſail upon, but either more to the right hand or to the left, according as the Variation is towards the right hand, or towards the left, and that ſo much towards the one ſide, or towards the other as that Variation is: We ſpeak not here of *Lee-ward* way, but of the Variation only. Therefore for the ſolution of this *Problem*, you muſt know how much the variation is, and which way; and how this may be done, we have briefly ſhewed upon the 12 Caſe of *right angled Spherical Triangles*, and the 11 of *oblique*, which known, you may find the angle of the *Rumb* or line of your ſhips way with the *Meridian*, being the thing in this *Problem* required.

A Table of the Angles of every Point and half Point of the Compaſs with the Meridian.

			D. M.		
	North.	*South.*	00 00	*North.*	*South.*
½			05 37		
1	*N* by *E*	*S* by *W*	11 15	*N* by *W*	*S* by *E*
1½			16 52		
2	*N N E*	*S S W*	22 30	*N N W*	*S S E*
2½			28 07		
3	*N E* by *N*	*S W* by *S*	33 45	*N W* by *N*	*S E* by *S*
3½			39 22		
4	*N E*	*S W*	45 00	*N W*	*S E*
4½			50 37		
5	*N E* by *E*	*S W* by *W*	56 15	*N W* by *W*	*S E* by *E*
5½			61 52		
6	*E N E*	*W S W*	67 30	*W N W*	*E S E*
6½			73 07		
7	*E* by *N*	*W* by *S*	78 45	*W* by *N*	*E* by *S*
7½			84 22		
8	*East.*	*West.*	90 00	*West.*	*East.*
	Add Eaſt Variation, Subſtract Weſt.			Add Weſt Variation, Subſtract Eaſt.	

For

For the effecting whereof, we will ſet down two ways; the one by the Pen alone, the other inſtrumentally. If you do it by the Pen alone, although it be not hard to find what Angle every Point or half Point makes with the Meridian; yet for your further eaſe herein, I have expreſſed the ſame in the Table before-going; the quarters of Points I have omitted, becauſe the Steerage upon a quarter of a Point is very uncertain (the Points being undivided as uſually they are) for a man by his eye is able to gueſs very nearly which is the middle between two points, but he cannot gueſs very nearly which is the fourth part. Yet if you deſire any quarter, you may add to the next before-going almoſt 3 *degrees*, namely, 2 *degr.* 49 *min.*

Now then by the Magnetical Rumb or Point of the Compaſs and Variation given, to find the true Rumb, you are to obſerve theſe two Rules following.

1. *If the Rumb and the Variation be both the ſame way from the Meridian* (*namely, both to the right hand, or both to the left*) *add them together, and that ſum is the true Rumb from that part of the Meridian.*

Yet if that ſum exceed 90 degrees, *Subſtract it from* 180 degrees, *the remainder is the Rumb from the oppoſite part of the Meridian.*

2. *If the one be towards the right hand, the other towards the left, Subſtract the Variation from the Rumb, and the remainder is the true Rumb.*

Yet if the Rumb be the ſmaller number, Subſtract it from the Variation, and the remainder is the true Rumb the other way.

Theſe rules we ſhall endevour to illuſtrate by examples following

But firſt for diſtinction ſake, we ſay the Rumbs or *degrees* from the North towards the Eaſt, are towards the right hand, and ſo from the South towards the Weſt; but from the North to the Weſtwards, on the left hand, and ſo from the South Eaſtwards: For a mans face being towards the North, the Eaſt is on his right hand, and the Weſt on his left, *&c.*

In like ſort for the *variation of the Compaſs*, if it have Eaſterly *variation*, that is, if the *Needle* and *Flower de luce* of the *Card* ſtand

ſtand to the Eaſtwards of the North, we ſay that *variation* is towards the right hand, for not only the North Point, but all the other Points of the Compaſs direct a Courſe more towards the right hand than they would do, if there were no *variation*. And ſo if it have Weſterly *variation*; that is, if the *Needle* and *Flower de luce* ſtand to the Weſtwards of the true North Point of the Horizon, we ſay that *variation* is towards the left hand; foraſmuch as not only the North-point, but all the other Points of the Compaſs, ſtand more towards the left hand than they would do, if there were no *variation*: This being premiſed, we come to give *Examples* of the two Rules before-going.

1. Let the Magnetical Rumb or Point of the Compaſs be Northeaſt, and the *variation* 10 *degrees* to the Eaſtwards; I demand the true Rumb?

Here the Rumb and Variation are both one way; that is, both towards the right hand; therefore,

To the Magnetical Rumb being N. Eaſterly	45 *deg.* 0 *m.*
Add the Variation Eaſterly	10 *deg.* 0 *m.*
The ſum is the true Rumb N. Eaſterly	55 *deg.* 0 *m.*

2. Admit a Ship Sail upon the North Point of the Compaſs, and that the Variation be 10 *degr.* to the Eaſtwards, how doth ſhe make her way?

The Magnetical Rumb is North, that is,	00 *deg.* 0 *m.*
To which adding the Eaſterly Variation	10 *deg.* 0 *m.*
The ſum is the angle from the North part of the Meridian to the Eaſtwards—	10 *deg.* 0 *m.*

Which is almoſt *N* by *E*, and ſo hath the Ship made her way.

3. Let the Point of the Compaſs be Eaſt ½ Point Northerly, that is, from the North to the Eaſtwards 7½ Points, which is 84 *degr.* 22 *min.* and the Variation as before 10 *deg.* to the Eaſtwards, I demand the true Rumb?

To the Magnetical Rumb being Northeaſt,	84 *deg.* 22 *m.*
Add the Eaſterly Variation	10 *deg.* 00 *m.*
The ſum is the angle from the North	94 *deg.* 22 *m.*
Which ſubſtracted from	180 *deg.* 00 *m.*
There reſts the true Rumb South eaſterly	85 *deg.* 38 *m.*

4 *Example.*

4. *Example.* Let the Courſe by the Compaſs be Weſt and by South, that is, 7 Points from the South to the Weſtwards, or 78 *deg.* 45 *min.* and let the Variation be as before 10 *deg.* to the Eaſtwards, what is the true Rumb?

To the Magnetical Rumb South Weſterly	78 *deg.* 45 *min.*
Add the Eaſterly Variation	10 *deg.* 00 *min.*
The ſum is the true Rumb Southweſterly	88 *deg.* 45 *min.*

You may conceive that the Rumb and Variation are here both one way: namely, both from the Meridian towards the right hand. For the Variation of the North Point is from the North towards the Eaſt, and conſequently of the South Point from the South towards the Weſt, both towards the right hand of the Meridian, as the Rumb is.

5 *Example.* Let the Courſe by the Compaſs be Weſt, that is, from the South to the Weſtwards 8 Points or 90 *degrees*, and let the Variation be as before 10 *deg.* to the Eaſtwards, I would know the true Courſe or Rumb?

To the Magnetical Rumb Southweſt	90 *deg.* 0 *min.*
Add the Variation Eaſterly	10 *deg.* 0 *min.*
The ſum is the angle with the South part of the Meridian.	100 *deg.* 0 *min.*
Which Subſtracted from	180 *deg.* 0 *min.*
There reſts the true Rumb N. *W.*	80 *deg.* 0 *min.*

Let the Courſe by the Compaſs be Weſt, that is, from the North to the Weſtwards 8 Points or 90 *degrees*, and let the Variation be 10 *d.* to the Weſtwards: I demand the true Rumb?

To the Magnetical Rumb Northweſt	90 *deg.* 0 *min.*
Add the Nariation Weſterly	10 *deg.* 0 *min.*
The ſum is	100 *deg.* 0 *min.*
Which Subſtracted from	180 *deg.* 0 *min.*
There remains the true Rumb Southweſt	80 *deg.* 0 *min.*

Object. The Magnetical Rumb being here Weſt 90 *deg.* why ſhould it not as well be counted from the S. as from the North.

Anſ. It may be counted from either, for as it is counted here from the North to the Weſtwards it falls under the firſt Rule, becauſe

becauſe the Variation is the ſame way: But if it be reckoned from the South to the Weſtwards, it falls under the ſecond Rule, whereof we now come to give ſome Examples, ſuppoſing theſe already given ſufficient to illuſtrate the firſt Rule.

7 *Example.* Let the Point of the Compaſs be N N W, and the Variation 10 *deg* Eaſterly, I demand the true Rumb:

From the magnetical Rumb N W	22 *deg.* 30 *min.*
Subſtract the Eaſterly Variation	10 *deg.* 00 *min.*
The Remainder is the true Rumb N W	12 *deg.* 30 *min.*

8 *Example.* Let the Point of the Compaſs be North, and the Variation Eaſterly 10 *deg.* what is the true Rumb?

From the Eaſterly Variation	10 *deg.* 00 *min.*
Subſtract the magnetical Rumb N W	00 *deg.* 00 *min.*
The Remainder is the true Rumb, the other way, namely N E	10 *deg.* 00 *min.*

Object. The magnetical Rumb may as well be named North-eaſterly 0 *deg.* 0 *min.*

Anſw. It may, but then it is ſubject to the firſt Rule, as in the ſecond *Example.*

9 *Example.* Let the Courſe by the Compaſs be Weſt, that is, from the North to the Weſtwards 8 Points, or 90 *degrees*, and let the Variation be as before 10 *degrees* to the Eaſtwards, what is the true Rumb?

From the magnetical Rumb N W	90 *deg.* 00 *min.*
Subſtract the Eaſterly Variation	10 *deg.* 00 *min.*
There reſts the true Rumb N W	80 *deg.* 00 *min.*

Here the magnetical Rumb might as well have been South-weſterly 90 *degr.* and ſo it had fallen under the firſt Rule, as in the fifth Example.

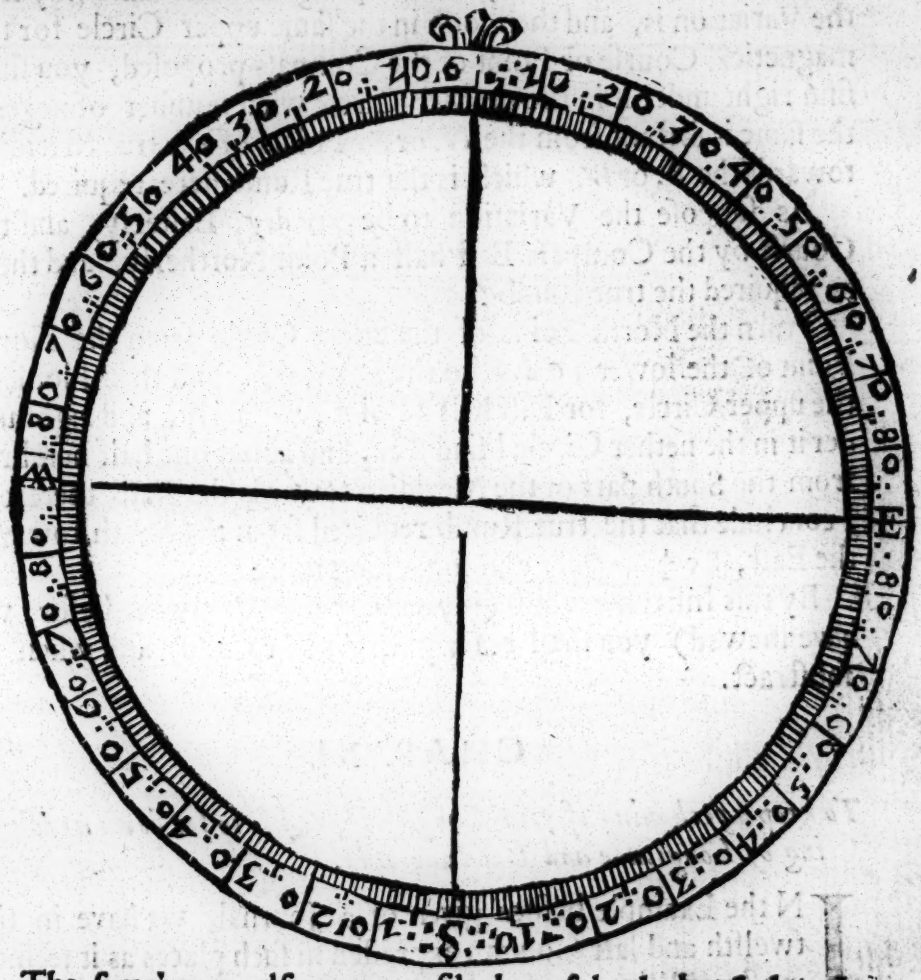
10 *Example.* Let the Courſe by the Compaſs be Weſt; that is, from the South to the Weſtwards 8 Points or 90 *degrees*, and let the Variation be 10 *deg.* to the Weſtwards, I demand the true Rumb?

From the magnetical Rumb S W	90 *deg.* 00 *min.*
Subſtract the Weſterly Variation	10 *deg.* 00 *min.*
The remainder is the true Rumb S W	80 *deg.* 00 *min.*

If

If the Rumb here had been reckoned from the North, as in the ſixth Example, it had fallen under the firſt Rule.

And this may ſuffice for the illuſtration of the two former Rules in the ſolution of this Problem.



The ſame may alſo more eaſily be reſolved, by ſuch an Inſtrument as is here deſcribed, conſiſting of two Circles, the one being the nethermoſt divided into four Quadrants, and every of thoſe into 90 *deg.* numbred from the North and South Points, towards the Eaſt and Weſt.

The other being the uppermoſt and moveable about the *Centre* divided; as the Card of the Compaſs into XXXII Points, and thoſe again ſub-divided into halves and quarters.

By this you may readily find the true Rumb for any Courſe and Variation given.

For if you turn the North Point of the upper Circle, from the North Point of the lower, ſo many *deg.* and the ſame way that the Variation is, and then look in the ſame upper Circle for the magnetical Courſe or Point of the Compaſs propoſed, you ſhall find right under it in the neather Circle what number of *degrees* the ſame is diſtant from the *N.* or *S.* Points of the true Meridian towards the *E.* or *W.* which is the true Rumb here required.

As ſuppoſe the Variation to be 10 *deg.* Eaſterly, and the Courſe by the Compaſs Eaſt half a Point Northerly, and there be required the true Rumb?

I turn the North Point of the upper Circle from the North Point of the lower 10 *deg.* to the Eaſtwards, and then I look in the upper Circle, for Eaſt half a Point Northerly, and right under it in the nether Circle I find 85 *d.* and about one half numbred from the South part of the Meridian towards the Eaſt, therefore I conclude that the true Rumb required from the South towards the Eaſt, $85\frac{1}{2}$ *degrees* and ſomething more.

By this Inſtrument alſo (if you uſe the Pen only, as before we have ſhewed) you ſhall readily ſee when to add, and when to ſubſtract.

CHAP. XI.

To keep a reckoning of your Longitude, and ſo to ſet down a reckoning by Longitude and Latitude only.

IN the Example before given of a Journal, we have in the twelfth and laſt Column expreſſed in ſuch places as it ſeemed moſt requiſite, the Longitudes, we come now to ſhew how the ſame may be known, and firſt,

By the Rumb & latitudes given, to find the difference of longitudes.

As *Radius* is in Proportion, to the Tangent of the Rumb;
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As let the Rumb be North-eaſterly 48 *deg.* and ſuppoſe a Ship to run upon this Rumb, from the Latitude of 32 *deg.* 25 *min.*

into

into the Latitude of 34 *deg.* 24 *min.* there is required the difference of Longitude. Here,

The Meridional parts answering to 34 *deg.* 24 *min.*			2200
The Meridional parts for	32	25	2058
The difference of Latitude in such parts is			141

Say then, as *Radius* is in proportion

To the Tangent of the *Rumb*, *t*, 48 *deg.* 0 *min.*		10.0456
So the difference of Latitude in Merid. parts	142	2.1523
To the difference of Longitude in Minutes	158	2.1979

These Minutes converted into *deg.* are 2 *deg.* 38 *min.* which is the difference of Longitude required, as the same is expressed in the Journal against the 21 of *February.*

And thus Sailing upon one and the same Rumb, you may find the difference of Longitude, and so often as you alter your Rumb, so often working by the same Rule, you shall have all the differences from place to place, which added together, make the whole difference of Longitude.

But you may also find the difference of Longitude near enough at one operation for many several Rumbs and Distances, provided that those Rumbs differ not much one from another. As in the former Journal from the 27 of *February*, till the 2 of *March*, I Sail by several Rumbs and Distances from the Latitude of 43 *deg.* 55 *min.* into the Latitude of 48 *deg.* if you would find the difference of Longitude hereto answerable at one operation, it may be done by this Rule.

As the difference of Longitude in Miles,
Is to the departure from the Meridian in Miles.
So is the difference of Latitude in Meridional parts,
To the difference of Longitude in Minutes.

As in that Example, the difference of Latitude for all those Courses, as in the North Column appears, is 2444.

The departure from the Meridian, as there in the East Column appears, is 6301.

The Merid. parts for the Latitude of 43 *deg.* 55 *m.* are	2939
The Merid. parts for the Latitude of 58 *deg.* 0 *m.* are	3292
Difference of Latitude in Meridional parts, is	353

Say then, As the difference of Latitude	2444	*co. ar.*	6.6119
To the departure from the Meridian	6301		3.7994
So the difference of Latit. in Merid. parts	353		2.5478
To the difference of Longitude in *min.*	910		2.9591

Which reduced into *degrees*, is 15 *deg.* 10 *min.* And added to the former Longitude 21 *deg.* 28 *min.*

Gives the preſent Longitude 36 *deg.* 38 *m.* for the 2 of *March.*

The like may be done for the account from the 2 of *March*, to the 5 of the ſame, *&c.*

But if your Courſes and Diſtances run, be all near to one and the ſame Parallel of Latitude (as in this Journal they are from the 5 of *March* to the 8) and from the 8 to the 10, then it is ſufficient to find what Longitude in that Parallel is anſwerable to the miles of Eaſting or Weſting, or departure from the Meridian by this Rule.

As the Sine Complement of the Latitude of that Parallel,
Is in proportion to *Radius*;
So is the number of Miles in that Parallel,
To the difference of Longitude in Minutes.

As from the 5 of *March* to the 8, the Latitude was near 50 *deg.* the Eaſterly diſtance 186 $\frac{8}{10}$ miles: therefore for the difference of Longitude, ſay:

As Sine Complement the Latitude, *s. c.* 50 *deg.* 0 *min.*			1919
To *Radius*,			
So is the departure from the Meridian	186	8	3.2714
To the difference of Longitude	290	6	3.4633

Thus it appears, the difference of Longitude is almoſt 291 *min.* which is 4 *deg.* 51 *min.* and this added to the Longitude upon the 5 of *March*, namely, to 46 *deg.* 52 *min.* the ſum is 51 *deg.* 43 *min.* the Longitude upon the 8 of *March*: the like might be done for the 20 of *March.*

And though this laſt Rule be then fitteſt to be uſed, when your Courſe is near Eaſt and Weſt, or your difference of Latitude little, yet it may alſo be uſed at other times inſtead of the two former, without any great Errour, if you take the middle *degree* of Latitude, or ſomewhat more, as in the former Example.

The

The Latitude upon the 27 of *Febrnary* is 43 *deg.* 55 *min.*
The Latitude upon the 2 of *March* is 48 *deg.* 00 *min.*
The middle Latitude, or ſomewhat more is 46 *deg.* 10 *min.*
Say then, as ſine Comp. the Latitude *s. c.* 46 *deg.* 10 *m.* 1595
To Radius.
So the Eaſting or departure from the Merid 630. 1. 3. 7994
to the difference of Longitude, 909. 7. 3. 9589

Which is almoſt 910 *min.* or 15 *deg.* 10 *min.* as before.

And thus you may in the 12 and laſt Column of your Journal ſet down your Longitude ſo often as you think it requiſite; and ſo in the two laſt Columns you ſhall have the ſubſtance and principal ſcope of your Reckoning, namely, your Latitudes and Longitudes, which whenſoever you deſire to ſet down in *Mercator's Chart*, or in the *Polar Chart*, or in any other graduated with *degrees* of Longitude and Latitude, you may readily do it.

As if I would ſet down the ſum of the foreſaid Journal from the 19 of *February* to the 10 of *March*, I find againſt the 10 of *March* the Latitude to be 49 *deg.* 54 *min.* and the difference of Longitude 54 *deg.* 53 *min.* Therefore in the Latitude of 49 *deg.* 54 *min.* I draw an occult Parallel, and reckoning from the *Summers-Iſlands* towards the Eaſt 54 *deg.* 53 *min.* I draw by that Longitude an occult Meridian, the Interſection of this Meridian with the foreſaid Parallel, is the Traverſe-point, or the Point repreſenting the place of the Ship, and the like is to be underſtood of any other.

This form of keeping and expreſſing a Reckoning, is (as I conceive) moſt apt and agreeable (of all others that I have ſeen or thought upon) to all ſorts of *Charts* or Maps, and to the *Globe* it ſelf; and to all the kinds or ways of Sailing, that are or may be uſed. We will here add ſome other Propoſitions which may ſometimes be of good and neceſſary uſe in it.

The Rumb and Difference of Latitude given: to find by the Table the Diſtance in the Rumb, and the Departure from the Meridian thereto anſwerable, &c.

HOw to find the Northing or Southing, that is, the diſtance in Latitude; as alſo the Eaſting or Weſting, that is, the Diſtance.

ſtance in Longitude, or departure from the Meridian of any Rumb, for any diſtance run upon it we have before ſhewed, the like operation is in theſe Propoſitions following: namely,

2. *The Rumb and diſtance in Latitude given: to find the diſtance in the Rumb, and the Eaſting or Weſting.*

3. *The diſtance and difference in Latitude given: to find the departure from the Meridian and the Rumb.*

4. *The difference in Latitude, and departure from the Meridian given: to find the Courſe and Diſtance.*

5. *The Courſe and departure from the Meridian given: to find the difference of Latitude and Diſtance.*

6. *The diſtance and departure from the Meridian given: to find the Courſe and difference of Latitude.*

So that with the firſt before-handled, here are ſix Propoſitions; and in every of them two things required; and ſo they become 12. We will not ſtand to give examples of them all, but only of thoſe which are moſt uſeful, the reſt may by them be conceived.

And firſt, to find the Eaſting or Weſting of any Rumb for any difference of Latitude.

Admit a Ship run North-eaſterly 60 *deg.* (that is N *E* by *E*, and almoſt half Point Eaſterly) till ſhe have altered the Latitude 42 *min.* how much is ſhe departed from the Meridian?

I run down the Column under 60. *deg.* till I find 42 miles, or 420 tenths, and againſt it in the adjacent Column I find 728 tenths, that is almoſt 73 miles, which is the departure from the Meridian to the Eaſtwards.

If you would alſo have the diſtance upon the Rumb, it is right againſt theſe numbers in the Column of Diſtances, being in this Example 84 miles.

2 *Example.* But admit ſhe run North-eaſterly 60 *deg.* till ſhe alter her Latitude 1 *deg.* 32 *min.* what is the Eaſterly diſtance?

This 1 *deg.* 32 *min.* is 92 miles, or 920 tenths, for which if I look in the Col. under 60 *d.* I find no number ſo great, but the greateſt number there is 500, which ſubſtracted from 920, there remains 420, therefore in that Column under 60 *deg.*

100	500	826
84	420	728
184	920	1594.

I look for theſe two numbers, namely, 500, and 420, and againſt the firſt in the adjacent Column I find 86, and againſt the ſecond 728, which I ſet againſt them as above appeareth, and ſo adding them, I find for this difference of Latitude, the departure from the Meridian to be $159\frac{4}{10}$ miles.

If further you deſire the diſtance run upon this Rumb, you have it in the Column of Diſtances, right againſt the ſame numbers, as in the example above appeareth, where being added, it amounts to 184 miles.

The diſtance and difference in Latitude given: to find the Rumb and departure from the Meridian.

ADmit a Ship run upon ſome Rumb between the North and the Eaſt 84 miles, and then have altered her Latitude 42 *min.* the Queſtion is, upon what Rumb hath ſhe run, and how many miles is ſhe to the Eaſtwards in Longitude?

I run croſs the Table towards the right hand, looking in every firſt Column of Diſtances for 84, till I find againſt it in one of adjacent Columns 420, at the top of which Column over 420, there is 60 *deg.* ſhewing the Rumb to be North-eaſterly 60 *deg.* alſo againſt 420 in the adjacent Column I find 728, which ſheweth the diſtance to the Eaſtwards to be almoſt 73 miles.

2 *Example.* But if the diſtance run be 184 miles, and the difference of Latitude 1 *deg.* 32 *min.* and there be required the Rumb and Diſtance to the Eaſtwards.

Becauſe the column of Diſtances extends but to 100 miles, and the diſtance here given 184 miles, you may take the half thereof, which is 92 miles, and likewiſe the half of 1 *deg.* 32 *min.* which is 46 miles, or 460 tenths, and then look, as before, where you find 460 againſt 92, for there in the top of the Column you ſhall find the Rumb, which in this example is 60 *deg.* ſhewing that the Rumb is from the N. eaſterly 60 *deg.* and in the adjacent Column againſt 92 and 460, you ſhall find 797, which doubled (becauſe it is for the half) is 1594, ſhewing that the departure from the Meridian to the Eaſtwards is $159\frac{4}{10}$ miles. Theſe and the reſt may alſo be performed by the *Doctrine of plain Triangles*, as we have formerly ſhewed.

CHAP.

CHAP. XII.

Certain Problems touching Currents.

ALthough the time be already expired which I aſſigned for this Work, and mine own more urgent occaſions call me away, yet ſeeing it is neceſſary in *Navigation* to take notice of Currents, and to make a competent allowance for them: I will briefly ſet down certain *Problems*, ſuch as I have ſometimes thought upon, whereby a man may the better conceive and judge of that allowance, the rather for that I know not any that have handled it.

Firſt then, it is to be conceived, that a Ship or other Veſſel Sailing or Rowing where there is a Current, hath a compound motion ariſing of two different Principles; namely of the Current and Ships way, ſo that here are three motions to be conſidered, namely, two ſimple, and the third compounded of them. The firſt ſimple motion is that of the Current, whereby it moveth, and is apt to move other things that are in it the ſame way. The 2 of the Ship or Boat, as it moveth by wind or Oars, or is apt to be moved, if there were no Current. The 3 compounded of them, is the Line of the Ships true motion. The 1, we call the way, or motion of the Current: The 2, the way, or ſimple motion of the Ship: The 3, her compound or true way. The 2 ſimple motions being either of them according to right Lines and uniform (as in the *Problems* following we ſuppoſe them to be.) The third alſo, which is compoſed of them is a right Line; for whether the Ship Sail directly oppoſite againſt the Current, or directly with it the ſame way, or whether the one croſs the other at right Angles or at oblique, yet ſtill either motion being direct and uniform, they both together beget a right lined uniform motion, becauſe the one retaineth to the other the one and the ſame proportion in every Point. And according to theſe grounds we proceed in the *Prob.* following, to determine the proportions of every of theſe motions, and the Angles which they make one with another. 1. *Ad-*

1 *Admit a Current run East 3 Miles an hour, and that a Ship under Sail run West directly against in 6 Miles an hour in her ſimple motion, what is her true or compound motion?*

From the Ships ſimple motion	6 miles
Subſtract the Current	3 miles
The Remainder is the Ships true motion	3 miles

So the Ships true way is to the Weſtwards 3 miles an hour.

2 *Admit a Current run West 6 Miles an hour, and that a Ship under Sail run directly againſt it 5 Miles an hour by the Log: what is the Ships compound motion, and which way?*

From the Current being the greater	6 miles
Subſtract the Ships ſimple motion	5 miles
The Remainder is the Ships true motion	1 mile

Which 1 mile ſhews, that the Ship by her compound motion falls a Stern, that is, moves to the Weſtwards 1 mile an hour.

In the experimental Practice of the two former *Problems*, it may ſeem, that a Ship or Boat ſo ordered, hath alſo a motion to the right hand, or to the left, but this comes to paſs, becauſe it is hard, and in a manner impoſſible to Stem a Tide or Stream ſo exactly, but that the Ship will ſwerve, (or yaw as they ſay) either to the one ſide or to the other.

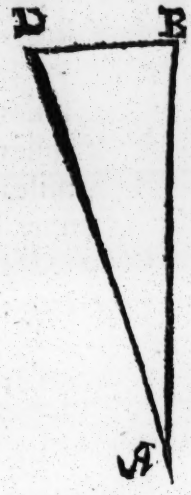
3 *Admit a Current run East 3 Miles an hour, and that the Ship alſo run East 3 Miles an hour by the Log: what is the Ships true motion?*

To the Ships ſimple motion	3 miles
Add the Current	3 miles
The ſum is the Ships true motion	6 miles

So the Ships compound or true way is East 6 miles an hour.

4 *Admit a Current run East 2 Miles an hour, and the Ship South 6 Miles an hour: what is the Ships true motion, and which way?*

In handling of any Art, to avoid circumlocution, there are uſed Terms or Words of Art, ſerving to expreſs briefly the things handled. And foraſmuch as this Subject hath not been formerly handled, nor the Principles or Grounds thereof laid (ſo far as I know) we will add a few ſuch terms as may ſeem moſt neceſſary, preſſing here what we mean by them.



Let the Line *A B* run from *A* to the Southwards, and *BD* from *B* to the Eaſtwards, and let *A B* be in proportion to *BD*, as 6 to 2, or 3 to 1.

Then doth *AB* repreſent the line of the ſhips ſimple motion, *BD* the motion of the Current, and *AD* the compound motion of the Ship.

And *D A B* is the Angle contained between the line of the Ships ſimple motion, and the line of her compound or true motion, which for brevity ſake we will henceforth call the *Angle of Deflection*. Alſo *ADB* is the angle contained between the Line of the Ships compound motion, and the ſet or drift of the Current, which we will call the *Angle of Reflection*.

Laſtly, *A B D* is the Angle contained between the Line of the Ships ſimple motion, and the ſet of the Current, which we will call the *Angle of Incidence*.

Then for the Rumb, the Proportion is thus.

As the ſimple motion	*A B* 6 miles	*co. ar.*	9.2219
Is to the Current	*B D* 2 miles		0.3011
So is *Radius*			
To the Tangent of Deflection *t D A B*	18 *deg.* 26 *min.*		9.5230

So the Rumb upon which the Ship makes her way good is South 18 *deg.* 26 *min.* Eaſterly, that is, S S E 4 *deg.* 4 *min.* Southerly.

2. *For the Ships true way, or compound motion.*

As the Sine of the Deflection *s D A B*	18 *deg.* 26 *min.*		0.5000
To the Current	*D B* 2 miles		0.3011
So *Radius*			
To the true motion	*A D* $6\frac{33}{100}$		0.8011

So the Ships compound motion is $6\frac{33}{100}$ miles hourly, that is, $6\frac{1}{3}$ miles almoſt.

5. *A Ship ſails Weſt 5 days together by the* Log. 725 *miles, but there is a Current, all this while ſetting to the Southwards* $1\frac{1}{2}$ *miles an hour: I demand how ſhe hath ſailed, and how far?*

The Current ſetting $1\frac{1}{2}$ miles an hour, ſets in 5 days 180 miles: Therefore, As

As the ſimple motion.	*A B* 725 miles	7.1397
Is to the Current	*D B* 180 miles	2.2553
So is *Radius*,		
To the Tangent of Deflection	*t D A B* 13 *d.* 57 *m.*	9.3950

For the Diſtance.

As ſine compl. the Deflection	*s c D A B* 13 *d.* 57 *m.*	0.0130
Is to the ſimple motion *A B*	725 *min.*	2.8603
So is *Radius*		
To the compound motion *A D*, 747 miles		2.8733

So the Ships true way is Weſt Southerly 13 *deg.* 57 *min.* or Southweſterly 76 *deg.* 3 *min.* 747 miles.

6. *A Ship ſails Weſt* 5 *days together by the* Log 725 *miles, in a Current ſetting to the Southwards, and then finds that he hath altered his Latitude* 3 degrees; *I demand the motion of the Current, the true* Rumb, *and true way of the Ship?*

This Queſtion differeth little from the former, for ſeeing the difference of Latitudes is 3 *deg.* the motion of the Current is 180 miles: ſo there is given the Ships ſimple motion, and the motion of the Current, as before, *&c.*

7. *A ſhip in* 6 *hours ſails from a certain* Cape *or Head-land South* 30 *miles by the* Log, *in a Current ſetting Eaſterly, and then obſerving the ſame* Cape, *he finds that it bears* N N W; *I demand how faſt that Current ſets, and how far he hath ſailed?*

As let a Ship ſail from A towards B South 30 miles, but by means of the Current, ſhe is driven more Eaſterly, namely to D, from whence ſetting the Cape A, it is found to bear *N NW.* And ſeeing the Current ſets from B towards D Eaſterly; therefore the angle of Reflection B D A is 6 Points, that is, 67 *deg.* 30 *min.* Here then is demanded the diſtance A D, and the drift of the Current in that time B D.

As the ſine of the angle of Reflection	*s* B D A 67 *d.* 30 *m.*	.0334
To the ſimple motion of the Ship A B 30 miles		1.4771
So the ſine of the angle of Deflection	*s* D A B 22 *d.* 30 *m.*	9.5736
To the motion of the Current B D 12$\frac{16}{100}$		1.0851

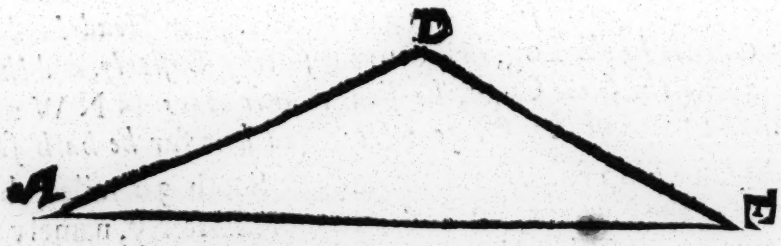
And further,

As the ſine of the angle of Reflection *s B D A* 67 *d.* 30 *m.* 0344
To the diſtance run by the Log *A B* 30 miles, 1.4771
So is *Radius*
To the compound motion of the Ship *A D*, 32 $\frac{47}{100}$ 1.5115

And thus we find that Current to ſet 12 $\frac{16}{100}$; that is, near 12$\frac{1}{6}$ miles in 6 hours, and the diſtance run to be 32$\frac{1}{2}$ miles almoſt.

That the thing may be the better conceived, we will two or three Examples more familiar and obvious to every mans experience; yet grounded upon the ſame Principles and Reaſons.

8 *Admit that* Tulis-ſtairs *near from* Billingſgate-ſtairs *South-weſt Southerly, namely, Southweſterly* 40 degrees, *and be diſtant* 80 *Poles: and ſuppoſe the Tide Ebb of to run there Eaſtward* 2$\frac{1}{2}$ *Miles an hour, and that a pair of Oars, rowing* 4$\frac{1}{2}$ *Miles an hour, would go ſtraight over from the firſt to the ſecond: how ſhall they row over, namely, upon what* degree *or Point of the Compaſs, and how far ſhall they row to get thither, and in what time?*



Let *A* repreſent *Billingſgate-ſtairs*, *D Tulis-ſtairs*, *A E* the ſimple motion of the Boat, *E D* the motion of the Current, then is *A* the angle of Deflection; *E* the angle of Incidence; *D* the angle of Reflection 130 *deg.* 50 *min.*

As the ſimple motion of the Boat *A E* 4$\frac{1}{2}$ miles 9.34679
Is to the motion of the Tide *D E* 2$\frac{1}{2}$ miles 0.39794
So the Sine of Reflection *D s* 50 *deg.* 9.88425
To the Sine of Deflection *A s* 23 *d.* 3 *m.* 9.62898

Thus then the Poſition, from *A* to *D*, being Southweſterly 40 *deg.*

deg. and the angle of Deflection *A* 23 *d.* 3 *m.* the poſition from *A* towards *E*, is South-weſterly 63 *deg.* 3 *min.* that is, *WSW* Southerly. And ſo muſt thoſe Oars row to go ſtraight over.

Secondly, for the diſtance A E.

From the angle of Reflection	*D*	50 *deg.* 00 *min.*
Subſtract the angle of Deflection	*A*	23 *deg.* 03 *min.*
And there reſts the angle of Incidence	*E*	26 *deg.* 57 *min.*

As the ſine of Incidence	*s E* 26 *d.* 57 *m*	0.34370
Is to the true diſtance	*A D* 80 Poles	1.90309
So the Sine of Reflection	*s D* 50 *deg.* 0 *min.*	9.88425
To the ſimple motion	*A E* 135 $\frac{2}{10}$ Poles	2.13104

Laſtly, for the time, ſeeing 320 Poles make a Mile, and they row, 4$\frac{1}{2}$ miles an hour, it is 1440 Poles in an hour: ſo the proportion is,

As the ſimple hourly motion	1440	6.8416
To the ſimple motion before found	135$\frac{2}{10}$	2.1310
So is an hour in Minutes, namely,	60 *min.*	1.7781
To the time required in Minutes	5 $\frac{63}{100}$	0.7507

And ſo long will they be Rowing.

9 *But ſuppoſe they will row harder, to go a ſhorter cut; namely, to go Southweſt by Weſt: how faſt muſt they go to row ſtraight over, and how far, and in what time?*

Then ſeeing the Poſition from *A* to *D* is South-weſterly 40. *deg.* and Southweſt by Weſt is South-weſterly 56 *deg.* 15 *min.* therefore the angle of Deflection at *A*, is 16 *deg.* 15 *min.* the angle of Reflection *D* as before, 50 *deg.* 0 *min.* the angle of Incidence *E* is 33 *deg.* 45 *min.*

As the Sine of Deflection	*s A* 16 *deg.* 15 *min.*	55311
To the motion of the tide	*D E* 2$\frac{1}{2}$ miles	0.39794
To the Sine of the angle of Reflection	*D* 50 *deg.* 0 *m.*	9.88425
To the ſimple hourly motion of the Boat	*A E* 6$\frac{844}{1000}$	0.85430

And ſuch is the hourly motion of the Boat, namely, 6$\frac{844}{1000}$ miles in an hour.

Secondly,

Secondly, for the ſimple motion.

As the Sine of Incidence	*s* E 33 *d.* 45 *m*	0.25526
Is to the true diſtance	A D 80 Poles	1.90309
So the Sine of Reflection D 50 *deg.* 0 *min.*		9.88425
To the ſimple motion A E 110$\frac{1}{10}$ Poles		2.04260

Thus it appears they muſt Row 110$\frac{1}{10}$ Poles to get over.

Laſtly, for the time.

The hourly motion before found 6$\frac{844}{1000}$ reduced into Poles, is		2190$\frac{1}{10}$
As the ſimple hourly motion	2190	6.65956
Is in proportion to an hour, or	60 *min.*	1.77815
So is the ſimple motion before found	110$\frac{1}{10}$	2.04260
To the time required	3$\frac{022}{1000}$ *min.*	0.48031

And ſo long will they be rowing over.

10. *But admit a Sculler rowing* 3 *miles an hour, would croſs ſtraight over at the ſame time, upon what Point muſt he row, and how far to get thither, and in what time will he do it?*

Firſt, *For the angle of Poſition.*

As the hourly motion of the Boat A E 3 miles		9.52288
To the Sine of Reflection	D *s* 50 *deg.*	988425
So is the hourly motion of the ſtream D E 2$\frac{1}{2}$ *min.*		0.39794
To the Sine of Deflection	A *s* 39 *deg.* 40 *min.*	9.80507

Now ſeeing the poſition for *Billingſgate* to *Tulis ſtairs*, namely, from A to D, is by ſuppoſition to the Weſtwards of the South 40 *deg.* and the angle of Deflection A is here found to be 39 *deg.* 40 *min.* therefore the poſition from A to E, is from the South to the Weſtwards 79 *deg.* 40 *min.* which is *W* and by *S*, and almoſt 1 *deg.* Weſterly, and ſo muſt that *Sculler* row to go ſtraight over. Secondly, *For the diſtance* A E.

From the angle of Reflection	D	50 *deg.* 00 *min.*
Subſtracting the angle of Deflection	A	39 *deg.* 40 *min.*
There reſts the angle of Incidence	E	10 *deg.* 20 *min.*

As the Sine of Incidence	*s* E 10 *deg.* 20 *min.*	.74624
To the true diſtance	A D 80 Poles	1.90309
So is the Sine of Reflection	*s* D 50 *deg.* 0 *min.*	9.88425
To the ſimple motion A E	341$\frac{6}{10}$ p.	2.53358

And

And thus it appears, that though the diſtance of the two places be but 80 Poles, yet if according to the queſtion, he row but after 3 miles an hour, and the ſtream ſet after $2\frac{1}{2}$ miles an hour, then he muſt row $341\frac{6}{10}$ Poles to go the ſtraight way.

Laſtly, For the time.

Three Miles is 960 Poles, ſay then

As the ſimple hourly motion	960	7.01773
To the ſimple motion before found	$341\frac{6}{10}$	2.53358
So is an hour in minutes, namely,	60 *min.*	1.77815
To the time required in Minutes	$21\frac{21}{100}$	1.32946

And thus it appears that the time requiſite to row over, rowing 3 miles an hour; is $21\frac{21}{100}$ minutes, whereas we found before, that rowing there $4\frac{1}{2}$ miles an hour, they might row over in $5\frac{62}{100}$ minutes, which is little more than a fourth part of the time.

There might be other and that great variety of Queſtions of this nature propoſed and reſolved, many of good uſe in practice, which the Water-men by daily experience without other Rules, are able to gueſs at ſomething nearly, ſufficing for their occaſions: my intent in theſe is eſpecially to explicate the Compound motion of a Ship, or other Veſſel Sailing or Rowing where there is a Current; which by ſuch familiar Examples may ſeem more evident. I cannot inſiſt upon them by reaſon of mine other occaſions, nor ſpend that time in theſe here handled, which elſe I would have done; whence if any defect or miſtake ſhould ariſe, if the Reader be pleaſed to give me friendly notice of it, I ſhall as thankfully accept it, and reform it. We propoſe next a queſtion at Sea, which let be this.

11. *There is a Current at Sea ſetting Eaſt* 12 *miles in* 24 *hours, a Ship ſails in the ſame from a certain Port Weſt Southweſt* 6 *days, and then returning thence, and ſailing* N. E *and by North* 3 *days, falls with the Port from whence he firſt departed, I demand what his dead reckoning was outwards, and what back again, and how far theſe two Ports were aſunder, and upon what Point of the Compaſs?*

And

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As let the Current ſet from *E* towards *D*, and let the firſt Port be *A*, the ſecond *F*, and let the Courſe outward bound be repreſented by *A E*, and the Courſe homewards by *D A*, &c.

And foraſmuch as *D E* is an Eaſt and Weſt Line, and *A E* Weſt Southweſt, therefore the Angle at *E* is 22 *deg.* 30 *min.* and by the like reaſon, the Angle at *D* is 123 *deg.* 45 *min.* or 56 *deg.* 15 *min.* and the angle at *A* 33 *deg.* 45 *min.* and *E D* being the ſetting of the Current for 9 days, is 108 miles.

Firſt then, for the dead reckoning outward, namely A E.

As the Sine of the angle at *A* is	33 *deg.* 45 *min.*	.25526
To the Line *D E*	108 miles.	2.03342
So is the Sine of the angle at *D* is	56 *deg.* 15 *min.*	9.91985
To the Line *A E*	$16\frac{6}{10}$	2.20853

Thus *A E* his dead Reckoning outwards is $161\frac{6}{10}$

Seconaly, for A D.

As the Sine of the angle *D A E* is	33 *deg.* 45 *min.*	.25526
Is to the Line *D E*	108 miles	2.03342
So is the Sine of the angle *D E A* is	22 *deg.* 30 *min.*	9.58084
To the Line *A D*	$74\frac{4}{10}$ miles	1.87152

Which $74\frac{4}{10}$ miles is his dead Reckoning homewards.

Thirdly, for the angle D A F *or* D F A.

The ſide *A D* is found	$74\frac{4}{10}$ miles
The ſide *D F* for 3 days, is	36 miles
The ſum of both is	$110\frac{4}{10}$
Their Difference is	$38\frac{4}{10}$
The ſum of the angles *D A F* and *D F A*	56 *deg.* 15 *min.*
The half ſum is	28 *deg.* $7\frac{1}{2}$ *min.*

The

The Proportion.

As the ſum of the ſides	110 $\frac{4}{10}$	7.95703
Is t their difference	38 $\frac{4}{10}$	1.58433
So is the Tangent of	28 *deg.* 07 $\frac{1}{2}$	9.72706
To the Tangent of	10 *deg.* 32 *m.*	9.26932

Which added together, make the Angle *D F A* 38 *deg.* 39 $\frac{1}{2}$

And ſeeing the Rumb from *F* to *D* is Eaſt, and the angle *D F A* 38 *d.* 39 *m.* $\frac{1}{2}$, therefore the Rumb from *F* to *A* is to the Northwards of the Eaſt 38 *deg.* 39 *m.* $\frac{1}{2}$, that is N E by E almoſt half a Point Northerly, which is the *rumb* from the ſecond Port to the firſt. *Laſtly, for* A F *the diſtance of theſe two Points.*

As the Sine of the Angle *D F A*, *s* 38 *deg.* 39 $\frac{1}{2}$		.20434
To the dead Reckoning Homewards	*A D* 74 $\frac{4}{10}$ Miles	1.87152
So is the Sine of the Angle *D s* 56 *deg.* 15 *min.*		9.91985
To the Diſtance	*A F* 99 $\frac{00}{100}$ Miles	1.99571

Thus the true diſtance of thoſe two Ports is 99 Miles, and ſomewhat more.

Sundry other queſtions of like nature might be propoſed, which to him that well underſtandeth, theſe will not be difficult.

Theſe Principles a little inlarged, may further with a few Experiments be applyed in the diſcovery of ſome Myſteries in compound motions not yet divulged; though much endeavoured by ſundry Famous Men in ſeveral parts of *Europe*, but theſe we ſhall not touch at preſent.

12. *To find where there is a Current at Sea, alſo which way it ſets, and how faſt.*

THis may be done by comparing the Reckoning outwards with the Reckoning homewards, whereof we will give an Example or two.

Firſt, admit a Ship Sail from a certain Port, by one or ſeveral (Rumbs or Diſtances,) till ſhe arrive at a ſecond, and there find Reckoning by Courſe and Diſtance, that ſhe is more Southerly than the Port from which ſhe departed by 541 Miles, and more Weſterly by 145 Miles: Put by his Reckoning homewards,

wards, when he arrives again at the firſt place, he finds himſelf to the Northwards of the ſecond 541 Miles, as before, and to the Eaſtwards 305 Miles. Now ſuppoſing he were 3 days outwards bound, and 5 days homewards bound, I would know which way the Current ſets, and how faſt? Here, becauſe the Eaſterly diſtance homewards is greater than the Weſterly diſtance outwards, therefore from the Eaſterly diſtance 305 Miles, ſubſtract the Weſterly diſtance 145 Miles, the remainder being 160 Miles, is the motion of the Current to the Weſtwards.

And thus it appears, that the Current ſets to the Weſtwards, 160 Miles in eight days, that is, 20 Miles a day, or $\frac{1}{6}$ of a Mile every hour.

2. *Example.* Admit a Ship Sail from the *Summer-Iſlands*, by ſeveral Rumbs and Diſtances, till ſhe arrive at Cape *Codd* in *New-England*, namely, from the Eaſt part of the *Summer-Iſlands* (the Variation being allowed) firſt, North 20 Miles, and then NNW 150 Miles, the ſecond day N by W 180 Miles: the

	North.	South.	Eaſt.	Weſt.
North 20 Miles	20 0			
North NW 150 Miles	138 6	——	——	57 4
North by Weſt 180 Miles	136 5	——	——	35 1
North 90 Miles	90 0			
Northeaſt 88 Miles	62 2	——	62 2	
528 Miles	487 3		62 2	92. 5
				62. 2
				30. 3

third day North 90 Miles, the fourth day Northeaſt 88 Miles, and ſo arrive at Cape *Codd*: then by theſe Courſes and Diſtances we may gather by the foregoing Table, that Cape *Codd* ſhould by this Reckoning be to the Northwards 487 Miles: and to the Weſtwards 30 Miles, as here appears.

Now ſuppoſe ſhe Sail back again from Cape *Codd* towards the *Summer-Iſlands*, the firſt day SSW 150 Miles, the 2 day SSW 160 Miles, the third day S by W 130 Miles, the fourth day South 140 Miles, the fifth day Eaſt 110 Miles, and ſo be come again to the Eaſt part of the *Summer-Iſlands*. South

	North.	*South.*	*East.*	*West.*
South S W 150 Miles	——	138. 6	——	57. 4
South S W 160 Miles	——	147. 8	——	61. 3
South by W 130 Miles	——	127. 5	——	25. 3
South 140 Miles	——	140. 0	——	
East 110 Miles	——	——	110. 0	——
690 Miles		554. 0	110. 0	144. 0
				110. 0
				34. 0

Theſe Courſes and Diſtances make, as here appearth, the *Summer-Iſlands* to be to the Southwards of Cape *Cod* 554 miles, and to the Weſtwards 30 miles.

Therefore by this laſt Reckoning back again Cape *Codd* ſhould be to the Northwards of the *Summer Iſlands* 554 miles, and to the Eaſtwards 34 miles, whereas by the former Reckonings outwards, it was to the Northwards only 487 miles, and to the Weſtwards 30 miles; ſo that the difference of theſe two Reckonings outwards and back again, is 67 miles Northerly, and 64 miles Eaſterly, which ſheweth that the Current in that time, namely, in 9 days, hath ſet to the Northwards 67 miles, and to the Eaſtwards 64 miles; that is, Northeaſt little Northerly 93 miles, as by the fore-going Table doth appear, which is $10\frac{1}{3}$ miles every day.

And what we have here done by the Tables might have been done (as the fore-going Problems) by the *Doctrine of Plain Triangles.*

FINIS.

...ks Printed and ſold by Benjamin Hurlock, *over againſt* S. Magnus Church, *on* London-Bridge *near* Thames-ſtreet.

NOrwoods Doctrine of Triangles, with Logarithms, lately printed, exactly corrected, and much enlarged by the Author himſelf. *Norwood's Epitomy*, applyed to plain and *Mercator's* ſailing. *Safeguard of Sailers*, or *Great Rutter*, by *Ro. Norman*. *Sea-mans Secrets*. *Path way to perfect Sailing*, by *Rich. Polter*. *Pitiſcus* his *Doctrine of Triangles*, with Canons. *Navigator*, by Capt. *Charles Saltonſtal*, newly printed with additions, ſhewing the deceits of the *plain Charts* uſed in our time, and a way to prove the projection of any *plain Chart*. *Dary's* deſcription and uſe of the *Univerſal Quadrant*. *Sea-mans Dictionary*, or the Expoſition and Demonſtration of all the parts and things belonging to a Ship; by Sir *Hen. Manwaring*. *Sea-mans Companion*, teaching Arithmetick, Geometry, Trigonometry, Navigation aud Aſtronomy, by *M. Norwood*. Newly printed.

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The *Pilots Sea-Mirrour*, which is a *Compendium* of the largeſt *Waggoner*.

The Complete Ship-Wright, teaching the propertions uſed by experienced *Ship-wrights*, according to their cuſtom of Building, with the drawing of a Draught, the making and marking of a Bend of Moulds, *&c.* both by Arithmetick and Geometry, by *Edm. Buſhnel*.

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The Mariners Compaſs Rectifyed, a Book furniſhed with Tables of hour and Azimuth, uſeful in Navigation, calculated from 0 *deg.* to 60 *deg.* of Latitude, with the uſe of all Inſtruments in Navigation, By *Andrew Wakeley*.

The Mariners Magazine in *folio*, containing the Deſcription of the Scale of Scales, with the art of Navigation, Surveying, Gauging, Gunnery, Aſtronomy, Dyalling, Fortification. By Cap. *Sam. Sturmy*.

Mathematical Manual in *octavo*, by Mr. *Phillips*. Of Navigation, Gunnery, Dyalling, Surveying, Gauging: with a Table of Logarithms to 10000.

The Geometrical Sea-man, ſhewing the 3 kinds of Sailing by the true *Sea Chart*, *Mercator's Chart*, and by a great Circle, with 2 Traverſe Tables, added by *H. Phillips*.

The Boat-ſwains Art, ſhewing the Maſting and Rigging of any Ship By *H. Bond*

Maddam twas once my fortune
for to see yor: C yor: V yor: N & T

Womans Answ

Was it so kind S^r: said she ~~the~~
S^r you may O Q P & Y
my C my V my N & T

BAT

E Marshall 1673